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RECORDS OF OCEANOGRAPHIC WORKS IN JAPAN

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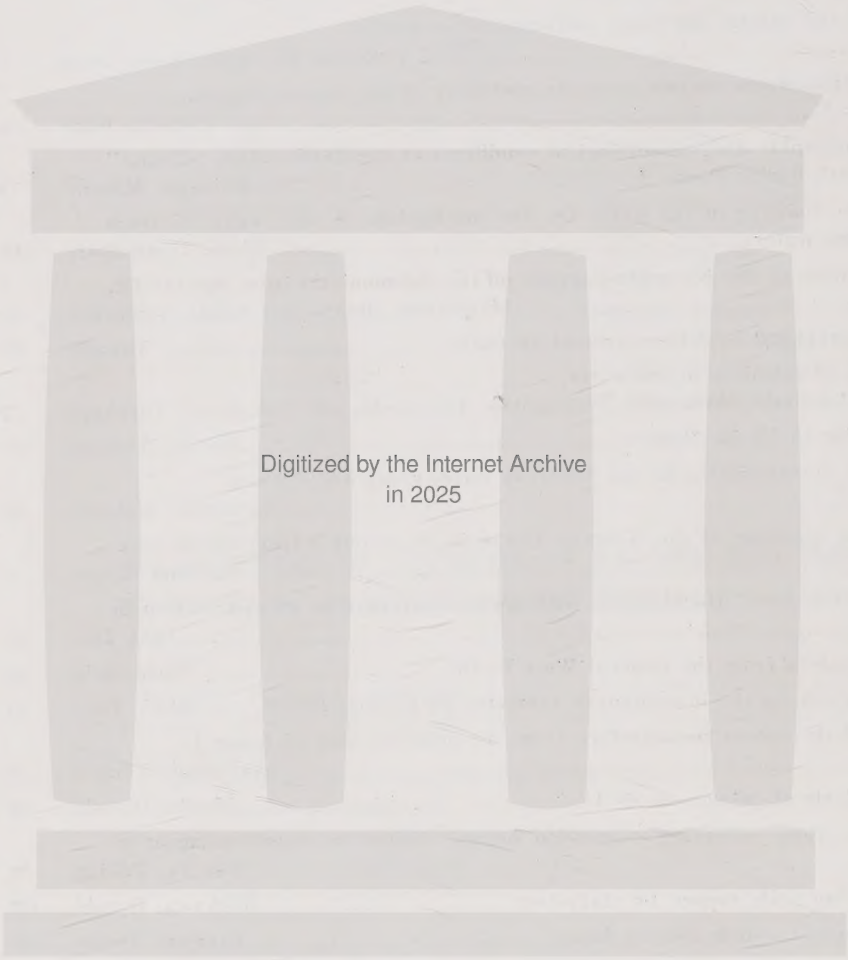

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Records of Oceanographic Works
in Japan, Vol. 1, No. 2,
New Series, December 1953

The Rising of the Coastal Sea Water Temperature in Winter

By Jiro Fukuoka and Iwao Tsuiki

Oceanographical Section, Central Meteorological Observatory

§ 1. *Preface.*

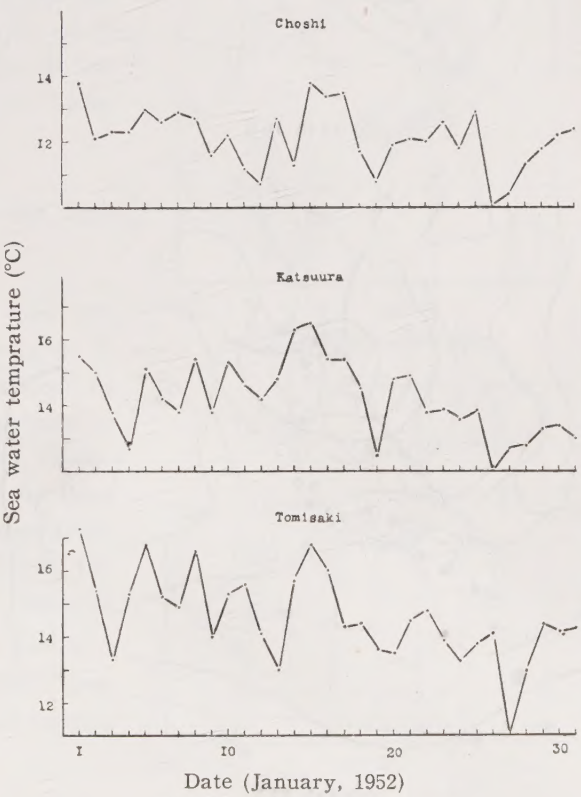
The coastal sea water temperature has been observed at many stations since 1930. By using these date, the variation of water temperature was studied along with the reasearch on water temperature variation in mid-ocean[1]. The authors studied the values of coastal sea water temperature of some stations and noticed an abrupt rising of the coastal sea water temperature in winter. In this paper authors intend to explain why the rising of the coastal sea water temperature takes place.

§ 2. *Coastal sea water temperature in winter at selected stations.*

Coastal sea water temperatures in January at Choshi, Katsuura and Tomisaki, all in Chiba Prefecture, are shown in fig. 1. The value of the coastal sea water temperature will generally be determined by solar radiation, air temperature, wind velocity, etc. In discussing the value of the coastal sea water temperature, it is neccessary to consider the effect of these meteorological factors. Here the authors intend to discuss the rising of sea water temperature caused by the wind.

Assuming that the rising of coastal sea water temperature is caused by the currents from the open sea, the authors

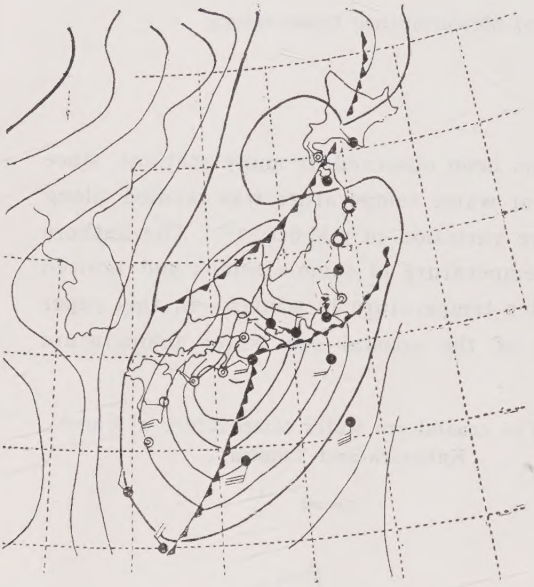
Fig 1. The coastal sea water temperature at Choshi, Katsuura and Tomisaki



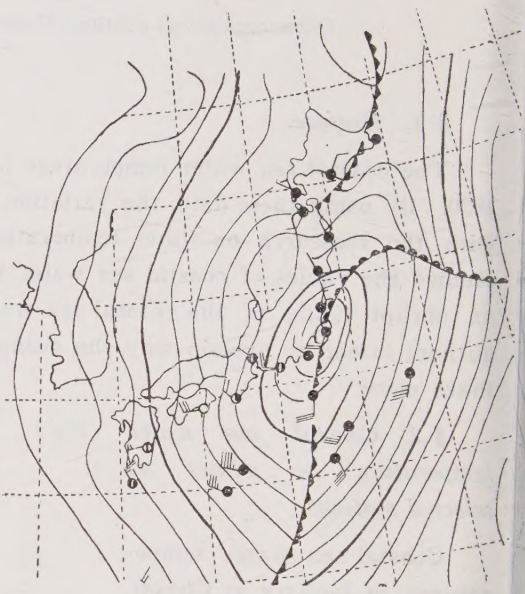
intended to describe the cause of the abrupt rise of coastal sea water temperature in the following discussions.

§ 3. *The relations between the abrupt rise of coastal sea water temperature and tee pattern of isobars.*

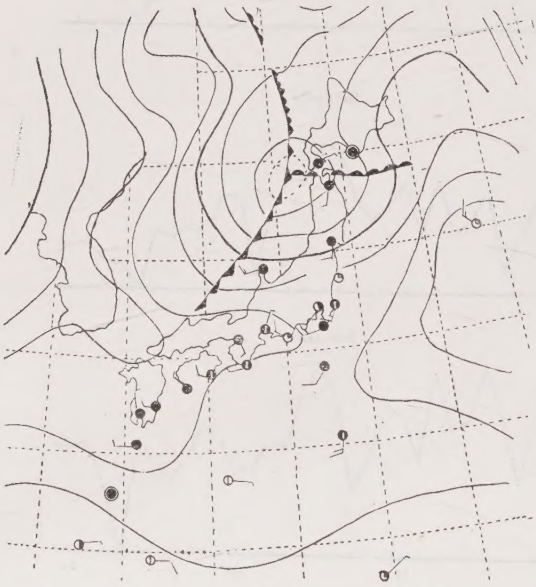
Fig. 2 Weather map. (January, 1952)



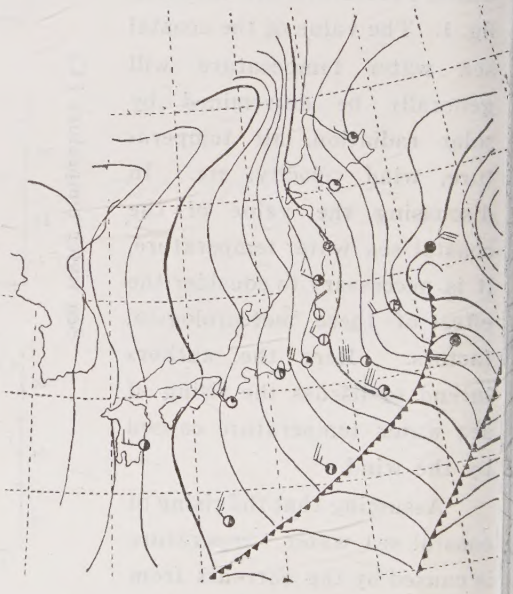
(b) 14 th 15 h



(b) 14 th 21 h



(a) 4 th 21 h



(c) 18 th 09 h

In the weather maps, figures 2(a) and 2(b), the abrupt sea water temperature rising may be related to the pattern of isobars. The sea water temperature falling is shown in figure 2(c) (isobar pattern). When these relations are described in reference to types of isobar pattern, there are, roughly speaking, two cases.

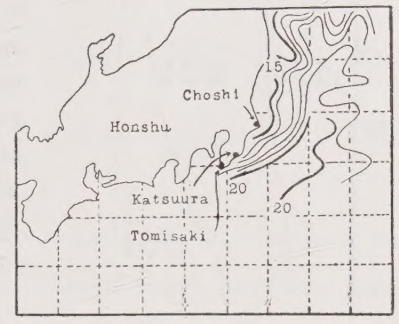
In the first case, the cyclone is developing and is going eastward across the Japan Sea. In the second case, the cyclone has originated near the east along China Continent progressing toward the the Pacific Ocean side of Honshu.

In figures 2(a) and (2b), a warm front extends in the east ward of the center of cyclones, and therefore strong south wind blows over the Pacific Ocean side of Honshu and over the adjacent sea. When the coastal sea water temperatures of Choshi, Katsuura and Tomisaki were investigated, it was noticed that the isobar patterns were connected with abrupt rising of coastal sea water temperature, and further the rising of sea water temperature may be to take place a few days before the time when the cyclones respectively reach the vicinity of the Boso Peninsula in the Pacific Ocean and the west of Akita Prefecture in the Japan Sea.

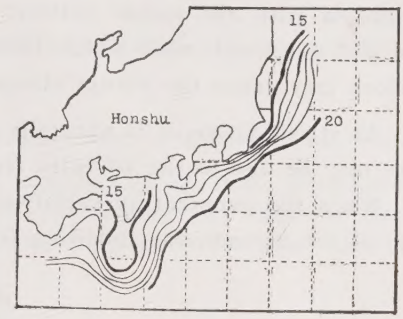
§ 4. *Water temperature in the open sea (the Pacific Ocean) in winter.*

Water temperature in the open sea (the Pacific Ocean) is shown in figure 3. isotherms are drawn for 10 day periods in January 1952. Isotherms extend parallel to the Honshu coastline from the Izu Peninsula and the cape Omaezaki to the Boso Peninsula. Moreover, water temperature tends to rise going from the coast to the sea. The temperature gradient becomes steep on the edge of the Kuroshio current. A similar condition has been observed in the vicinity of the Gulf Stream in the Atlantic Ocean.

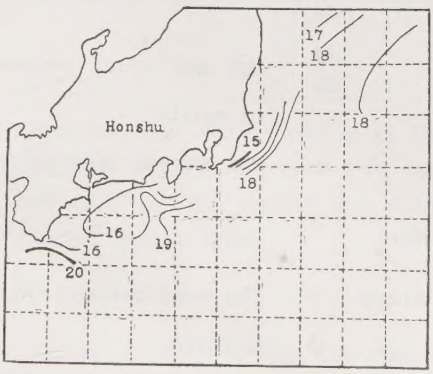
Fig. 3. The isotherms of surface water in January 1952



for period of 1st–10th



for period of 11th–20th



for period of 1st–31th

When convection develops in the sea in winter, the sea water temperature becomes uniform from the surface down to considerable depth of approximately 100 m. This fact is clear, according to the oceanographical observations in the south of the Cape Shionomisaki, Kii Peninsula. The depth—temperature diagrams, figure 4, are drawn for stations respectively about 10 miles and 20 miles south of the Cape Shionomisaki. It is apparent that the uniform water temperature appears in the same depth at both stations and extends in a belt of constant temperature from west to east in winter. From this fact we suppose that the coastal sea water temperature may be influenced by the sea water temperature of the open sea, when the strong south wind is blowing.

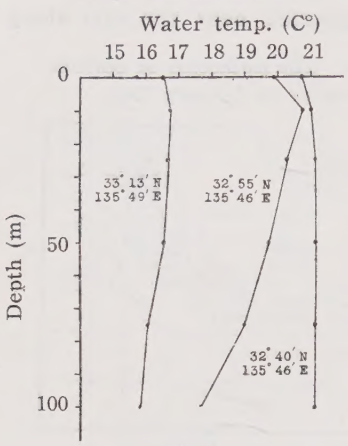


Fig. 4. Vertical distribution of Water temp. near the cape Shionomisaki

§ 5. *The coastal sea water temperature rising caused by advection*

It has already been stated that the coastal sea water temperature rising is connected with the isobar pattern. According to the weather maps, figures 2(a) and 2(b), the south wind which blows in company with the development of the cyclone may cause the abrupt change of the coastal sea water temperature.

As stated above, it is naturally inferred that the rising of sea water temperature may be due to the advectin from the open sea.

When the temperature variation with time is connected only with the advection of the current, the following formula will be applicable:

$$\frac{d\theta}{dt}=u\cdot\frac{d\theta}{dx},$$

where $\frac{d\theta}{dt}$: the variation of the coastal sea water temperature with time,

$\frac{d\theta}{dx}$: the sea water temperature gradient in the x-direction (from south to north)

u : the current velocity caused by the wind.

Here
$$u=\frac{0.0126\,W}{\sqrt{\sin\phi}},$$

where W : the wind velocity (m/s),

ϕ : latitude.

When the practical calculations are performed with the data observed at Tomisaki, the following results are obtained.

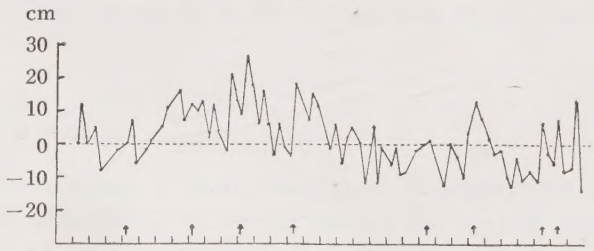
Date	$\frac{d\theta}{dt}$	$\times 10^{-6}$ °C/sec	W m/sec	$\frac{d\theta}{dx}$	$u\frac{d\theta}{dx}$	$\times 10^{-6}$ °C/sec
3rd— 5th	$\frac{5.5°C}{2\text{ days}}$	3.19	8	0.131	$\frac{5°C}{20\text{ S.M.}}$	1.77
7th— 8th	$\frac{1.6°C}{1\text{ day}}$	1.85	10	0.164	$\frac{5°C}{20\text{ S.M.}}$	2.22
13th—15th	$\frac{3.8°C}{2\text{ days}}$	2.20	12	0.197	$\frac{3.0°C}{20\text{ S.M.}}$	1.60
20th—22nd	$\frac{1.3°C}{2\text{ days}}$	0.75	6	0.099	$\frac{3.0°C}{20\text{ S.M.}}$	0.80
27th—29th	$\frac{3.6°C}{2\text{ days}}$	2.09	10	0.164	$\frac{3.0°C}{20\text{ S.M.}}$	1.32

Now the values of the wind velocity are taken from the weather maps, and the values of $\frac{d\theta}{dx}$ are obtained from the Kaikyo Jumpo (published by the Central Meteorological Observatory). The values of $u\cdot\frac{d\theta}{dx}$ are generally similar to the values of $\frac{d\theta}{dt}$ found at Tomisaki in January 1952.

§ 6. *One evidence indicated that the sea level at Tomisaki is raised by the current transported by wind.*

It is stated above that the rise of coastal sea water temperature was due to the advection from the open sea. The authors studied the sea level at Tomisaki. The differences between the astronomical tide and the observed tide are shown in figure 5. When the difference between these tides is large, the rise of coastal sea water tempetrature usually takes place. However, on January 5th the rise of coastal sea water temperature occured, while at the same time the difference between the astronomical tide and the observed tide was very small. In furture study the authors will find that the coastal sea water temperature rising is not coincident with the rise of the sea level.

Fig. 5. The difference height of the astronomical tide from the observational tide (January, 1952
↑ showing the water temperature rise



§ 7. *Conclusion.*

From the above explanations the authors intend to conclude that the rise of the coastal sea water temperature is due to the advection from the open sea.

Reference

(1) M. Hanzawa: On Some Examples of Abrupt Change of Oceanographical Conditions at the Ocean Weather Station 'Extra' Adjacent to the Oceanic Polar Front, *Oceanogr. Mag.* Vol. 4, No. 3, p. 67, 1952

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Annual Variation of Sea Surface Water Temperature in the Current Region

By Kozo Hishida

(Maizuru Marine Observatory)

1. Introduction

The character of annual variations of surface sea water temperature changes from one locality to another, but a few of the general features can be pointed out. (Mc Ewen, 1937) In the ocean current region, the current may be an important factor among a number of factors which affect the annual temperature variation. In this paper, theoretical considerations will be made on this problem, and then, by the application of the result the states of temperature in Kuroshio and Tsushima current will be discussed.

2. Theoretical considerations.

The continuity equation for the heat flow through the element in the ocean current may be expressed in the follwing form

$$D(c\rho\theta)/Dt = -divF - q. \tag{1}$$

Here, c is the specific heat; ρ, the density; θ, the temperature of sea water; F, the heat flow; and q, the loss of heat from the element per unit of time. Considering that the ocean current is horizontal, and that the heat flow in the horizontal direction is negligibly small compared to the vertical flow, F_z, we obtain from Eq. (1)

$$c\rho\left(\frac{\partial\theta}{\partial t}+u\frac{\partial\theta}{\partial x}\right) = -\frac{\partial F_z}{\partial z}-q, \tag{2}$$

where the z axis is upward and the x axis is along the current direction. Let Q be the amount of solar radiation penetrating to the sea surface per unit of time and assume the exponential law of extinction, then we have

$$-\frac{\partial F_z}{\partial z} = -\frac{\partial Qe^{-bz}}{\partial z} = Qbe^{-bz}, \tag{3}$$

where b is the extinction coefficient. The loss of amount of heat given off from the element by evaporation, back radiation, and mixing is assumed to be represented by the simple linear function, such that

$$q = kc(\theta-\bar{\theta}), \tag{4}$$

where k and $\bar{\theta}$ may be regarded as constants within the current region. This

procedure is similar to that employed by McEwen (1937). Consider the quantity of be^{-bz} as constant for moderate depth and put

$$be^{-bz}\equiv\beta,\quad \frac{1}{\rho}\left(\frac{Q\beta}{c}+k\bar{\theta}\right)\equiv w,\quad \frac{k}{\rho}\equiv\gamma,$$

then with these simplifications we obtain the fundamental differential equation of the following form:

$$\frac{\partial\theta}{\partial t}+u\frac{\partial\theta}{\partial x}=w-\gamma\theta. \tag{5}$$

Since the value of w may be considered as a function of time only within latitudes intervals, the solution of Eq. (5) becomes

$$\theta=e^{-\gamma t}\left\{\int e^{\gamma t}w(t)dt+f\left(t-\frac{x}{u}\right)\right\},\quad t>\frac{x}{u} \tag{6}$$

where f represents an arbitary function.

Take the origin of x axis at a suitable position, where the surface temperature variation is assumed to be shown by the following equation:

$$\theta=\theta_0+\theta_1\sin(\sigma t-\varepsilon)\quad\text{at}\quad x=0. \tag{7}$$

Here, θ_0 is the annual mean temperature; θ_1, the half annual range; ε, the phase; and $\sigma=\frac{\pi}{6}$ corresponds to the 12 month cycle. Then, with this boundary condition, Eq. (6) may be rewritten in the form:

$$\theta=\theta_0e^{-\gamma\xi}+\theta_1e^{+\gamma\xi}\sin[\sigma(t-\xi)+\Sigma]+e^{-\gamma t}\int_{t-\xi}^{t}e^{\gamma\eta}w(\eta)d\eta \tag{8}$$

where
$$\xi=x/u. \tag{9}$$

Assume the quantity of w to be proportional to the incident radiation, then we obtain

$$w=w_0+w_1\sin\sigma t, \tag{7'}$$

where w_0 and w_1 are the annual mean and the half annual range of w respectively. Then the value of ϵ in Eq. (7) is regarded as the phase lag of temperature behind incident radiation, and from Eq. (8) the following equation is obtained by integration:

$$\begin{aligned}\theta=\theta_0e^{-\gamma\xi}+\frac{w_0}{\gamma}(1-e^{-\gamma\xi})+\theta_1e^{-\gamma\xi}\sin\{\sigma(t-\xi)-\epsilon\}\\ +w_1\left\{\frac{\gamma\sin\sigma t-\sigma\cos\sigma t}{\gamma^2+\sigma^2}-e^{-\gamma\xi}\frac{\gamma\sin\sigma(t-\xi)-\sigma\cos\sigma t}{\gamma^2+\sigma^2}\right.\\ \left.-e^{-\xi\gamma}\frac{\gamma\sin\sigma(t-\xi)-\sigma\cos\sigma(t-\xi)}{\gamma^2+\sigma^2}\right\}.\end{aligned} \tag{10}$$

If we put

$$\delta=\tan^{-1}\sigma/\gamma, \tag{11}$$

Eq. (10) can be written as follows:

$$\theta=\theta_A+\theta_B$$

$$\theta_A=\theta_0 e^{-\gamma\xi}+\frac{w_0}{\gamma}(1-e^{-\gamma\xi}),$$

$$\theta_B=\theta_1 e^{-\gamma\xi}\sin\left\{\sigma(t-\xi)-\epsilon\right\}+w_1\frac{\sin\delta}{\sigma}\left[\sin(\sigma t-\delta)-e^{-\gamma\xi}\sin\left\{\sigma(t-\xi)-\delta\right\}\right]. \quad (12)$$

If as a special case the current velocity is considered to be very small, then we get from Eq. (12)

$$\theta=\frac{w_0}{\gamma_0}+\frac{w_1\cos\gamma}{\gamma}\sin(\sigma t-\delta), \quad (12\cdot1)$$

which is the same equation as introduced by Mc Ewen (1937) in the case of no current region, and also by Angstrom (1925) on the annual temperature variation of air.

3. Some applications.

According to the average monthly values of surface water temperature based on the results of observations made by Fisheries Institutes, annual surface temperature variations are investigated by using the harmonic analysis method at several stations in Kuroshio and in Tsushima current respectively, which are shown in Fig. (M. Uda, 1933) Computed vaues of the constant term, the first harmonic term, and the phase angle of annual changes at each stations are obtained as summarized in Table I.

Table 1. Computed values of annual mean, half annual range and phase angle of surface temperatures

(i) Kushiro								
No. of Stations	1	2	3	4	5	6	7	8
Position N	30.6	31.0	32.6	32.0	31.7	32.7	34.8	34.0
Position E	130.4	130.5	133.1	133.5	135.7	135.7	140.1	141.2
Annual mean (°C)	23.3	22.2	22.8	23.1	22.5	23.1	20.5	22.3
Half annual range(°C)	4.5	5.1	4.9	4.6	4.5	4.3	4.7	4.5
Phase angle (°)	216	217	216	215	206	212	204	206

(ii) Tsushima current									
No. of stations	1	2	3	4	5	6	7	8	9
Position N	34.0	34.8	34.5	35.5	35.2	36.0	36.7	38.8	38.8
Position E	129.6	130.3	130.8	131.7	131.5	135.8	135.7	138.8	139.3
Annual mean (°C)	20.0	19.1	19.7	18.7	18.9	17.4	17.4	16.5	16.5
Half annual range(°C)	6.4	5.9	6.1	6.4	6.5	8.1	7.8	8.2	8.2
Phase angle (°)	208	208	209	207	205	204	205	207	206

From the origin, which is taken at the western station in each currents, the distance is determined by the length of a projection to the line along which the current flows straight. Plot the above computed values against the distance in graphs, then the points fall almost on straight lines, leading to the relation such that

$$y=\beta_0+\beta_1 x,$$

, where β_0 and β_1 are a constant and the derived, taking 100 miles as the unit of distance. The significancy of the relation is also checked by the F-distribution method at the significant level of 5%. The results are presented in Table 2, on the basis of which the features of annual temperature variations will be discussed, referring to the theoretical considerations shown above.

Table 2. Changes with location of annual mean (θ_0), half annual range (θ_1), and phase angle (ε) of temperatures.

Current	Kuroshio			Tsushima current		
	θ_0	θ_1	ε	θ_0	θ_1	ε
Value at the origin (β_0)	23.1	4.75	217.3	19.7	5.95	207.0
Difference between 100 miles (β_1)	−0.26	−0.04	−2.25	−0.64	+0.49	−0.17
Value of F	8.2*	0.8	20*	60*	34*	2.5

Remark: The mark * means "significant."

(1) Annual range of temperature.

The difference of the annual change between unit distance in the current can be obtained approximately from θ_B in Eq. (12) in the following form:

$$\Delta\bar{\theta}_B=\gamma\xi\left[\frac{w_1\sin\delta}{\sigma}\sin\left\{\sigma(t-\xi)-\delta\right\}-\theta_1\sin\left\{\sigma(t-\xi)-\epsilon\right\}\right], \qquad (13)$$

where $\Delta\bar{\theta}_B$ is the difference of annual changes, since $\gamma\xi$ may be considered small compared to unit. With regards to the magnitude of annual range, the phase angle ε may be taken nearly equal to δ, and then Eq. (13) leads to

$$\Delta\theta_{BR}=\gamma\xi\left(\frac{w_1\sin\delta}{\sigma}-\theta_1\right), \qquad (13\cdot1)$$

where $\Delta\theta_{BR}$ represents the difference of the half annual range between unit distance.

Now, the current velocity per day may be taken to be 40 miles in kuroshio and 10 miles in Tsushima current in average. We may, then, evaluate the value of $\frac{w_1\sin\delta}{\sigma}$ in Eq. (13·1), referring to Eq. (9) and (II). If we presume $\delta=72°$ and

regard two cases such that the phase lag of w behind solar radiation is (i) null and (ii) 16°, then, since values of θ_1 and $\Delta\theta_{BR}$ are given in Table 2, the values of $w_1 \sin\delta/\sigma$ become (i) 2.0 and (ii) 3.4 in Kuroshio, and (i) 14.5, (ii) 9.0 in Tsushima current respectively.

Thus, the value of $\frac{w_1 \sin\delta}{\sigma}$ in Tsushima current is several times as large as that in Kuroshio, although the respective value of θ_1 is nearly equal. Hence, we may conclude that the remarkable chonge of annual range with location in Tsushima current is attributed in major degree to heat gain or loss in the course of current besides the current velocity, while in Kuroshio the conditions in the origidal locality is one of the important factors.

(2) Phase (Time of extreme value of temperature)

If the current velocity is taken the same as before, then the value of $\sigma\xi$ which may be considered approximately as the difierence of phase angle between unit distance from Eq. (12), becomes 2.5° in Kuroshio. This value is nearly equal to the computed value of 2.25° shown in Table 2. In Tsushima current, however, we get $\sigma\xi \fallingdotseq 10°$, which is fairly different from the computed one in Table 2. Hence, we may recognize the tendency that the term, containing ξ in the last equation of Eq. (12), affects the annual change to a great extent, while to some extent, in Tsushima current, this tendency is similar to the result on the annual range shown above in (I).

(3) Annual means of temperature

The difference of the annual mean temperature between the unit distance of 100 miles in the current, which is denoted by $\Delta\theta_A$, can be obtained from the second equation of Eq. (12) as follows:

$$\Delta\bar{\theta}_A \fallingdotseq \xi(\gamma\theta_0 - w_0) \tag{14}$$

since $\gamma\xi < 1$ as before. If we presume that the value of $(\gamma\theta_0 - w_0)$ in Eq. (14) are nearly equal in these currents, then the value of $\Delta\theta_A$ depends mainly upon the value of ξ. The current velocity being taken the same as before, the value of ξ in Kuroshio is only 25% of that in Tsushima current. This may explain satisfactorily the computed value of $\Delta\theta_A$, which is 0.26 in Kuroshio and 0.64 in Tsushima current as shown in Table 2. Therefore, the change of annual mean temperature with location is considered to be influenced appreciably by the velocity of the current.

4. *Conclusions*

Among the various factors which control the annual variation of surface water temperature in the ocean current region, the conditions in the original locality and the heat gain or loss which takes place in the path of the current under various meteorological conditions and mixing etc., are considered to be dominant.

By the solution of the differential equation of the heat flow at the surface layer in the ocean current, and its applications to the results obtained from the observation data in Kuroshio and in Tsushima currents, we are led to the conclusion that these factors may be responsible for the annual variation of surface temperature in a different manner in each current region, as shown in the changes of the annual mean, annual range, and time of extreme value of temperature in the current.

Acknowledgements

The writer is indebted to Dr. M. Uda, Dr. S. Kawakami, and Dr. H. Fujita for their kind advices.

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Records of Oceanographic Works
in Japan, Vol. 1, No. 2,
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On the oceanographic and meteorological conditions at the fixed station "Extra" in the North Pacific Ocean (Part 1)

By Masami Koizuni

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1. Since October 1947, maritime meteorological as well as oceanographic observations have been performed without interruption in spite of various diffculties by the Central Meteorological Observatory of Japan at a fixed station in the western part of the North Pacific Ocean, centered at 39°N, 153°E and called "Extra" or abbreviatedly "X". And an enormous amount of data has already been accumulated. If these abundant data are dealt with corresponding to the respective purposes of various kinds of investigations, many interesting and worthy results will be obtained.

A weather ship is not always fixed at the center but in most cases drifted here and there within the permissible circle of 50sm radius. Meteorological observations have been carried out every hour up to quite recently but afterwards 8 times a day. The points where the meteorological observations were performed are more or less scattered, but it will be allowed to consider that the distribution of these points has a parttern similar to that of the oceanographic stations, in regard to which the author described in the previous reports [1] [2]; the stations are so densely distributed around the center that 90% of them are within the area of 38°30′–39°30′N and 152°30′–153°30′E. However, in this paper the distribution of the stations will not be taken into consideration in particular except those which are located within the same limits as previously reported, *viz.* 38°–40°N and 152°–154°E.

2. Sea-surface temperature is most frequently observed in any region of the sea because of the simplicity of measurement, and also very ofted used in order to obtain informtion on a general trend of oceanograhic conditions. Therefore, it seems to be most necessary that the properties of sea-surface temperature are examined in detail from various points of view.

Here the sea-surface temperature as well as air temperature at the "Extra" are dealt with. In the first place, the daily means and then the moving averages of 11 days are computed for the two elements. Also, the monthly and yearly means are obtained. The moving averages and the monthly means are plotted in Figure 1. Some characteristic figures of the annual variations of both elements,

based on the monthly means, for instance, in the case of 1949, are given in Table 1, in which the corresponding figures for the fixed point "Tango" or shortly "T" (29°N, 135°E) [3] are also inserted for the sake of comparison, but they are based

Table 1 Some characteristic figures in the annual variation of air and sea-surface temperatures

St.	Element	Max. (time of occur.)	Min. (time of occur.)	Ann. range	Year. mean	Remarks
"X"	t_w	23.32 (Sept.)	10.46 (Mar.)	12.86	15.93	1949
	t_a	22.36 (Sept.)	4.99 (Mar.)	17.37	13.00	
"T"	t_w	27.58 (Aug.)	18.74 (Feb.)	8.84	22.95	From Jun. 1950 to May 1951. By Masuzawa [3]
	t_a	27.25 (Aug.)	15.86 (Feb.)	11.39	21.28	

t_w: sea-surface temperature in °C
t_a: air temperature in °C

on the data from June 1950 to May 1951. However, it is to be noted that the year of 1949 showed generally lower temperatures among the five years from 1948 to 1952, and in this year, the extremes and the annual range of the surface temperature were smaller than those of the monthly means of the five years. The annual ranges of air and sea-surface temperatures, especially of the former, are much greater at the "Extra" than at the "Tango". Since, in the North Pacific Ocean, the annual range of the sea-surface temperature generally reaches a maximum of about 10°C in the zone of about 40°N [4], the vicinity of the "Extra" with a range of more than 12°C is probably one of the regions with the greatest annual range of the sea-surface temperature in the whole ocean. The maximum of the sea-surface temperature occurred in September in the year of 1949, but in the remaining cases among the five years it took place in August, and the latter case as this may be considered as normal. The minimum of the surface temperature takes place ordinarily in March, but sometimes in February. The extremes of the air temperature occur generally in accordance with those of the surface temperature. The time of occurrence of the extremes at the "Extra" seems to be somewhat different from that of the "Tango".

In Table 2 are given the differences between the air and sea-surface temperatures, based on the monthly means. For the sake of comparison the differences for the "Tango" are also shown in Table 2. The sea-surface temperature is, as far as the monthly means are concerned, higher than the air temperature, though, as shown in Figure 1, in the moving averages the latter is sometimes higher than the former in summer season. Therefore, heat is, on a average, given off from the ocean to the atmosphere. The difference, $t_w - t_a$, is markedly large from late autumn to early spring, and in summer it is generally very small. With dry prevailing wind, such a large difference of temperature is expected to increase the evaporation in a marked degree. The period in which the surface temperature

Table 2 Differences between air and sea-surface temperatures (°C)

(By the monthly means)

$t_w - t_a$

St.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
"X"	5.0	4.9	5.5	2.3	0.4	1.4	0.1	0.5	1.0	2.4	5.0	6.6
"T"	3.3	2.9	2.8	1.0	0.8	0.6	0.2	0.3	0.4	1.4	1.8	4.6

t_w: sea-surface temperature.
t_a: air temperature.

is lower than the direct subsurface temperature almost coincides with that of the said large difference. The large amount of evaporation and the air temperature much lower than the surface temperature are to be very effectual on the rapid cooling of the sea surface.

Now, at a glance upon Figure 1, it is found that the series of the moving averages rise and fall with a shorter and more or less distinct period, being superimposed on the general annual variation. This may be associated with the meandering of the ocean currents, but still affords a scope for further investigation. The author intends to touch on this problem in a subsequent paper. Again, it is recognized that in the series of the moving averages the sea-surface temperature varies more smoothly than the air temperature. It is perceived from this that the air temperature is liable to fluctuate in a marked degree compared with the sea-surface temperature. In fact, the plotted daily means of the air temperature are particularly in winter notably scattered, whereas those of the sea-surface temperature generally deviate little from the course of its moving average. The larger fluctuation of the air temperature will be understood, if we consider the magnitudes of the density and specific heat of air and sea water, and also the speeds of the movements of air and water masses.

Finally, the monthly means of the surface temperature computed from all the observed values are compared with those obtained only from the values at the oceanographic stations where serial observations of oceanographic elements were made. The result for the year of 1949 is shown in Table 3. The difference, $t'_w - t_w$, falls mostly within the range of ± 0.5°C, while the case where the difference, $t'_a - t_a$, exceeds this range occur very frequently. The accuracy of such a mean as $t'_a(t'_w)$ in Table 3 may be unsatisfactory for some special purposes and for a better accuracy more abundant data will have to be taken into consideration in computation. J. Masuzawa [5], using the data of the sea-surface temperature at the "Tango", calculated the ranges within which the deviations of the mean temperature of several observations in a day from the daily mean (average of hourly observations) take place with the probability of 95%. According to his calculation, it is shown, for instance, that if we average four observations the probability with which the deviation of this mean from the daily mean exceeds the range of $\pm$

Table 3

Comparison of monthly mean of hourly-observed sea-surface (air) temperatures with mean of the observed sea-surface (air) temperatures at the time of oceanographic observations, $t'_w(t'_a)$.

1949	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
(°C)												
t_w	12.6	11.6	10.5	10.6	12.7	15.6	20.0	22.5	23.3	19.6	17.3	14.7
t_m'	13.0	11.7	10.2	10.9	12.8	16.2	20.3	22.3	23.4	19.6	17.4	15.1
$t_w'-t_w$	0.4	0.1	−0.3	0.3	0.1	0.6	0.3	−0.2	0.1	0.0	0.1	0.4
t_a	7.7	6.7	5.0	8.3	12.3	14.2	19.9	22.0	22.4	17.1	12.3	8.1
t_a'	7.9	6.3	6.0	7.7	12.4	14.6	20.6	21.7	22.5	16.9	11.4	7.7
$t_a'-t_a$	0.2	−0.4	1.0	−0.6	0.1	0.4	0.7	−0.3	0.1	−0.2	−0.9	−0.4
n	9	9	5	8	13	20	17	21	17	15	10	5

n: Numbers of oceanographic stations.

0.3°C is only 5%. Of course, the case he treated is concerned with the diurnal variation, and it is applicable to the regions such as the "Tango" where any variation besides the diurnal one is only small as a rule. For the case of the "Extra" where different water masses contact with each other and accordingly the variations of meteorological and oceanographic phenomena are intense and intricate, the more complicated methods will have to be applied. Anyhow it will be certain that in this case we must increase the number of data to be used in order to gain such an accuracy as mentioned above.

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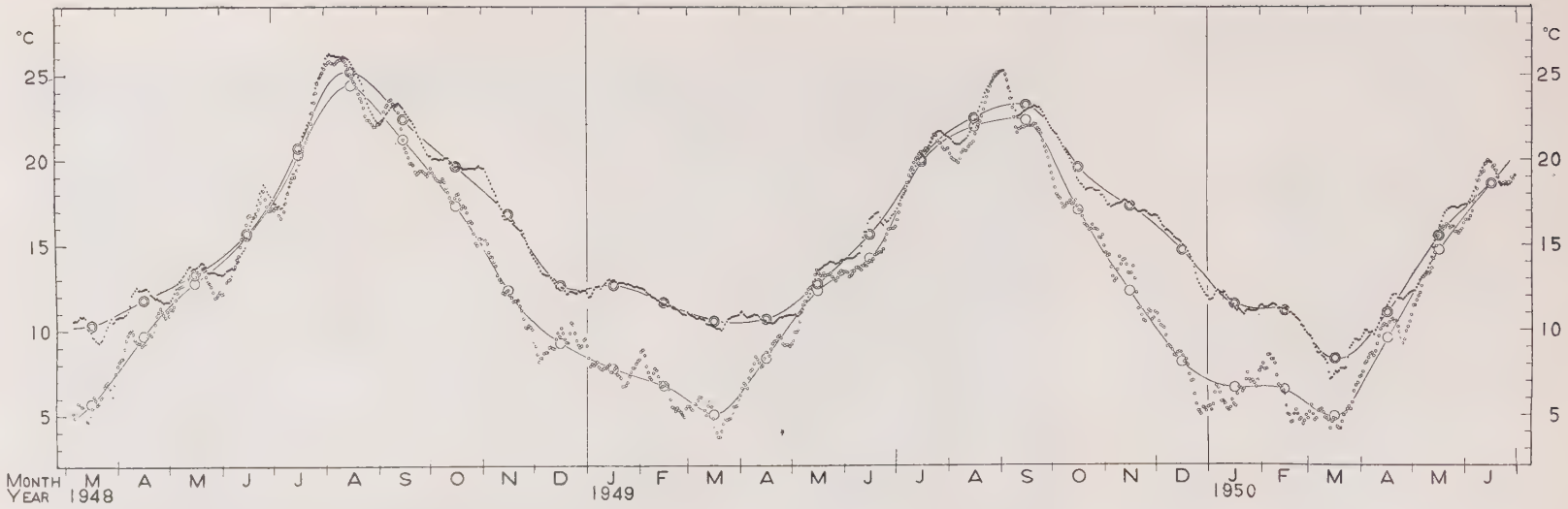

Fig. 1. The variations of the air and sea-surface temperatures at the fixed station "Extra" (30° N, 153° E) in the North Pacific Ocean from March 1948 to June 1949. The small circles represent the moving averages of 11 days, the open being for air temperature and the solid for sea-surface temperature. The large open circles and large double circles represent the monthly means of air and sea-surface temperature respectively.

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A study on the foaming of sea water
On the mechanism of the decay of foam layer of sea water

By Tomosaburo Abe

Oceanographic Laboratory, Meteorological Research Institute

§1. *Introduction*

In observation of surface conditions of the sea, Beanfort's scale is mainly used at present. Existence of white-chops produced by wind is the most important factor on this scale.

It is considered from our experimental results that the degrees of white-chops change with the chlorinity concentration of sea water, the temperature and the stability of foam. These experimental relationships have already been reported by Y. Miyake and T. Abe. In the present paper, the mechanism of the decay of foam layer of sea water has been experimentally studied.

§2. *Experimental procedure.*

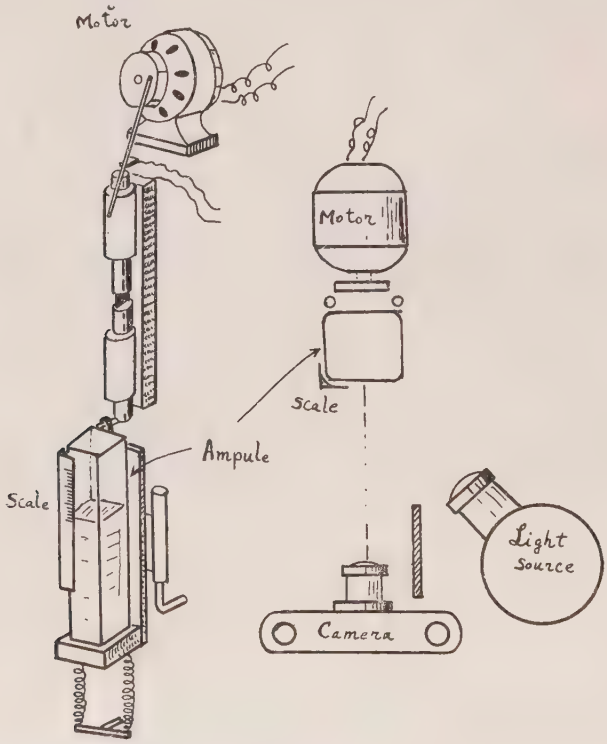
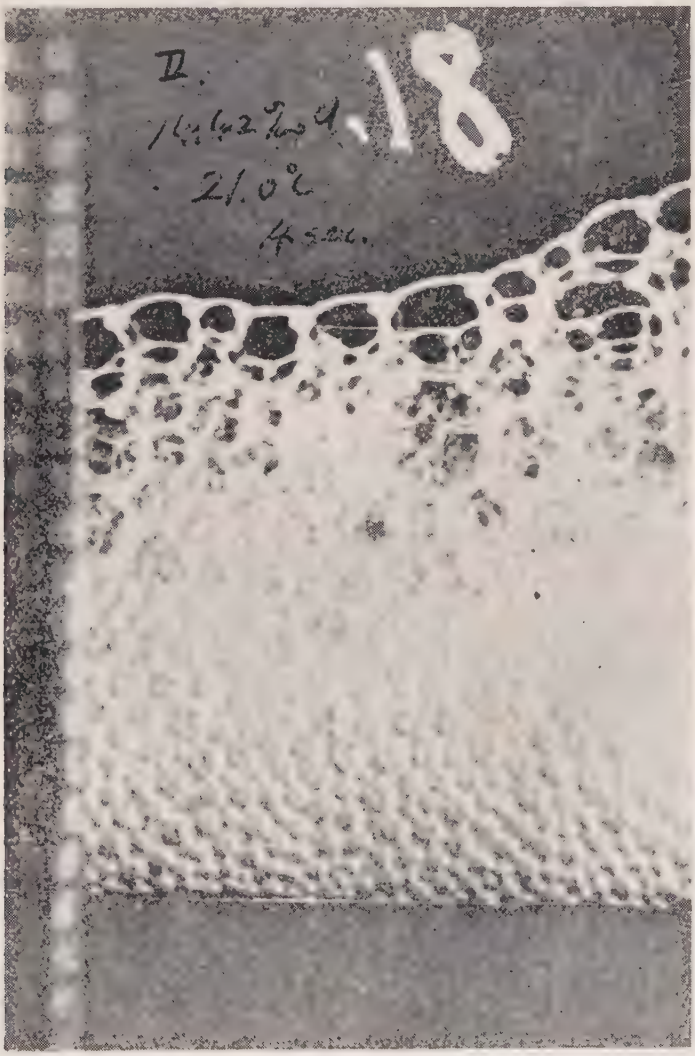


Fig. 1. Diagram of Apparatus

The glass ampule used in the present experiments has a square section of about $4 \times 4\,cm^2$ and about 15 cm in length. The ampule containing filtered sea water was vibrated up and down about 15 time per second in the amplitude 15 mm for about 30 seconds (Fig. 1). After the vibration was over, the features of foam layers were taken photograph illuminated by ultra high pressure mercury lamp. As soon as above procedures were over, the temperature of sea water was measured. All the apparatus were contained in a constant temperature room and kept at constant temperature within errors of $\pm 1°C$.

For the samples, the filtered natural sea water (19.26‰°Cl) and various ones which were prepared by diluting natural sea water in various degrees, were used. The experiments were done under the temperature of 29, 21, 14, and 5°C.



Photograph of Foam layer of Sea Water Cl. 14.42‰, after 4 sec.

§3. *Results and discussions.*

[1] **Relation between the height of foam layer and the time.**

All the samples show the analogous tendencies in reference to time, and so, for example, the case of sea water having the chlorinity concentration 14.42‰ at temperature of 28°C, is as follows:

The empirical relation between log h and t is shown in Fig. 2, where h is the height of foam layer (mm.) and t the time (sec.).

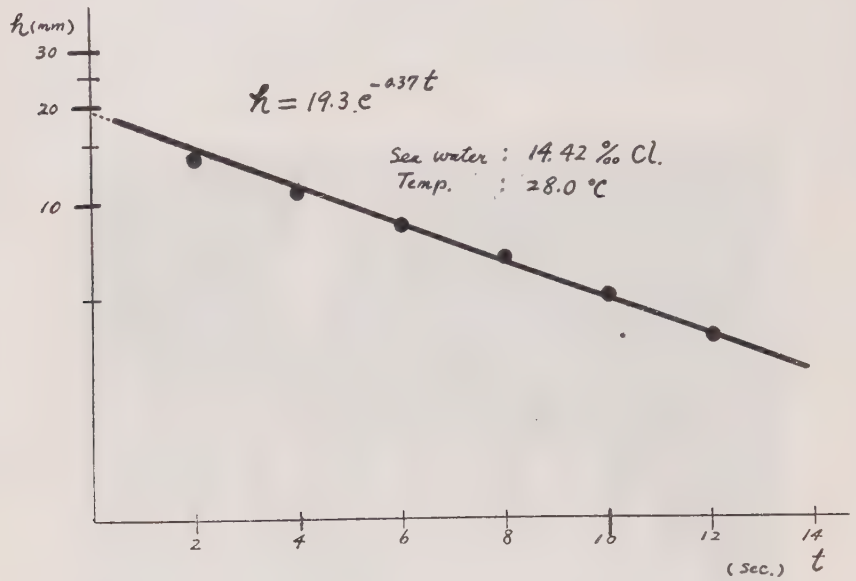


Fig. 2. Relation between the height of foam layer (h) and time (t)

Log h decreases linearly with increasing t, i.e.

$$h = h_0 e^{-kt} \tag{1}$$

where h_0 is the value of h at t=o, and k the decay constant of foam layer.

Hence by differentiating Eq. (1) with t, we have

$$\frac{dh}{dt} = -h_0 k e^{-kt} = -kh \tag{2}$$

That is, the speed of decay of foam layer is proportional to its height, and thus the type of the decay is that of the so-called "lst order chemical reaction". From Eq. (1), we can see that the time required for the height of foam layer to reduce to its half value, is constant. This corresponds to the half life τ, which is often used in the decay of radioactive elements. Hence from Eq. (1), we have

$$\frac{h_0}{2} = h_0 e^{-kt} \qquad \therefore \quad kt = \text{const} = 0.693$$

The results of measurements are given in Table 1.

Table. 1.

Chlorinity concentration ‰	Initial height of foam layer h_0(mm)	Decay const (**k**)	Half life τ(sec.)	Calculated value of **kt**
19.26	22.5	0.143	4.8	0.685
18.46	24.6	0.170	4.1	0.697
16.05	24.4	0.166	4.2	0.696
14.42	19.3	0.137	5.1	0.698
12.82	18.5	0.145	4.8	0.696
9.63	20.0	0.20	3.6	0.690

In the cases of sea water having chlorinity concentrations higher than 13‰, the value of τ is larger than that in the case of lower concentrations; that is, the foam layer is more stable in the former case than in the latter, and it does not decay easily. It was previously reported by us that foam is easily produced when the chlorinity of sea water has a comparatively large value, i.e. a value larger than 13‰ Cl., and the foam produced lasts longer. Thus, it is considered that in the sea regions with large chlorinity concentration, the white-chops easily appear, while in the sea regions with comparatively low chlorinity, i.e. lower than 9‰ Cl., the white-chops do not easily appear.

[2] **Changes in frequency distribution of the size of bubbles in foam layer.**

Frequency distributions of the size of bubbles at every 2 seconds were obtained, which are shown in Fig. 3. The size ranges of the bubbles were represented by

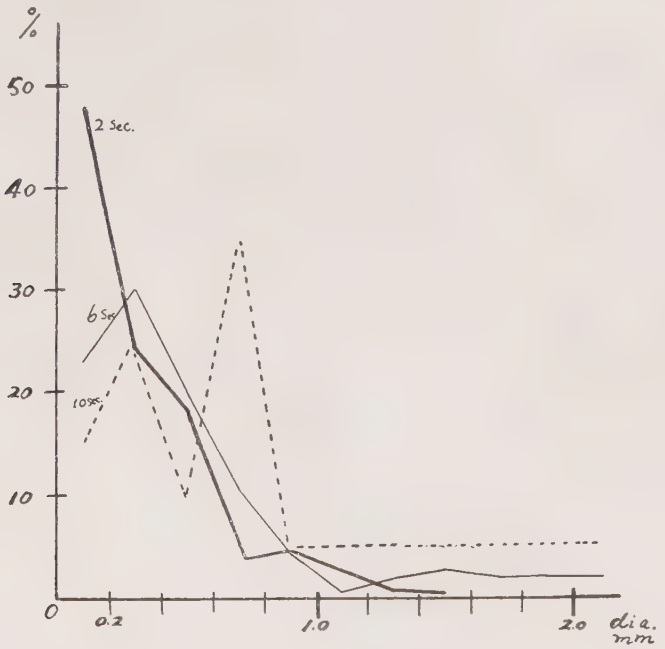


Fig. 3. Changes the frequency distribution of the size of bubble of foam layer

their median values. As seen in this figure, there is the bubble having maximum frequency at each stage and the size of it increases with time to a certain value

Table. 2.

Time (sec)	2	6	10
Dia. at max. frequ. (mm)	0.1	0.3	0.7
Max. frequ. (%)	48.0	30.5	35.0

(see Table 2). From Fig. 3, the changes of frequencies with time for various sizes of bubbles can be obtained, which are shown in Fig. 4.

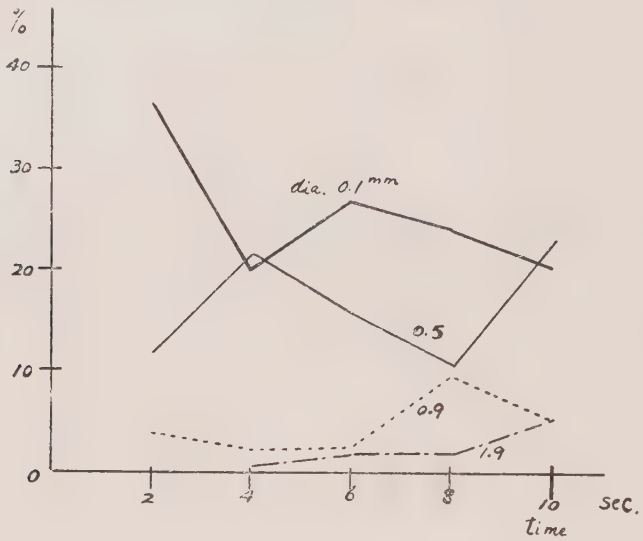


Fig. 4. Relation between the frequency distribution of bubble and time

[3] **Changes of the mean radius of bubbles in foam layer.**

The mean radius r was calculated by the following formula:

$\bar{r}=\sqrt{\frac{\sum n \cdot r^2}{\sum n}}$, where r is the radius of each bubble, and n the number of bubbles.

An empirical formula was found as follows:

$\bar{r}=C_1+C_2 \cdot t$, where C_1 and C_2 are const. and t is time.

In the case of sea water having chlorinity 14.42‰ at the temperature of 21°C, C_1 and C_2 are 0.33 and 0.018, respectively.

[4] **The mean life of a bubble in the foam layer.**

The distribution of the size of bubbles in the foam layer changes its form as shown in Fig. 8-a, where d is the diameter of the bubble, p the frequency and t the time ($t_1<t_2<t_3$, $t_2-t_1=t_3-t_2=2\delta$, δ is time element).

Let the frequencies of bubbles having diameter d_x, be $p_{x\cdot1}$ at t_1, $p_{x\cdot2}$ at t_2 and $p_{x\cdot3}$ at t_3. Eq. (1) gives:

$$h_1=h_0e^{-kt_1} \qquad h_2=h_0e^{-kt_2} \qquad h_3=h_0e^{-kt_3}$$

Put $h_1-h_2=\Delta h_{1\cdot2}$, $h_2-h_3=\Delta h_{2\cdot3}$; $\Delta h_{1\cdot2}$ is the decrease in foam height between

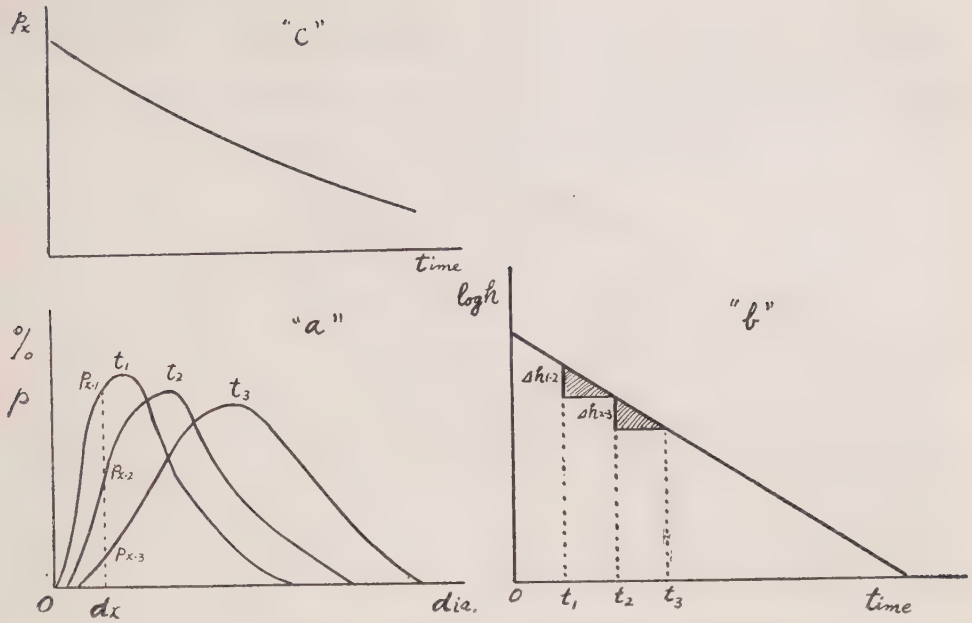


Fig. 5. Schematic diagram of determination of bubble life

t_1 and t_2, and the shaded parts of Fig. 5–b represent the amount proportional to the numbers of bubbles decayed in this time interval.

Then $$n_{1\cdot2}=k\cdot\Delta h_{1\cdot2}\cdot 2\delta/(\bar{d}_{1\cdot2})^2 \tag{5}$$

where k is a certain constant, $\bar{d}_{1\cdot2}$ the mean diameter corresponding to the time interval.

In a similar manner, we have:

$$n_{2\cdot3}=k\cdot\Delta h_{2\cdot3}\cdot 2\delta/(\bar{d}_{2\cdot3})^2 \tag{6}$$

Therefore from Eqs. (5) and (6), we have,

$$\frac{n_{2\cdot3}}{n_{1\cdot2}}=\frac{\Delta h_{2\cdot3}}{\Delta h_{1\cdot2}}\left(\frac{\bar{d}_{1\cdot2}}{d_{2\cdot3}}\right)^2 \tag{7}$$

Further, from $$\frac{\Delta h_{2\cdot3}}{\Delta h_{1\cdot2}}=e^{-2k\delta}$$

Eq. (7) becomes

$$\frac{n_{2\cdot3}}{n_{1\cdot2}}=e^{-2k\delta}\left(\frac{d_{1\cdot2}}{d_{2\cdot3}}\right)^2 \quad \text{or} \quad n_{2\cdot3}=e^{-2k\delta}\left(\frac{d_{1\cdot2}}{d_{2\cdot3}}\right)^2\cdot n_{1\cdot2}$$

Similarly, $$n_{3\cdot4}=e^{-2k\delta}\left(\frac{d_{2\cdot3}}{d_{3\cdot4}}\right)^2\cdot n_{2\cdot3}$$

therefore, the following recurrence formula is generally obtained:

$$n_{s\cdot(s+1)}=e^{-2k\delta}\left(\frac{d_{(s-1)\cdot s}}{d_{s\cdot(s+1)}}\right)^2\cdot n_{(s-1)\cdot s} \tag{8}$$

Among the number of bubbles which decayed between t_1 and t_2, the number of those whose diameter is d_x, is $n_{1\cdot 2}\ p_{x1}$, and the life of them are considered as $\frac{1}{2}(t_1+t_2)$ or $(t_1+\delta)$. And so if the mean life of the bubble is represented by τ_x, by the idea of expectation in probability,

$$\tau_x = \frac{\int_0^\infty t\cdot n_t p_x \cdot dt}{\int_0^\infty n_t \cdot p_x \cdot dt} \fallingdotseq \frac{\Sigma t_i \cdot n_i \cdot p_i}{\Sigma n_i \cdot p_i} \qquad (9)$$

τ_x can be calculated by substituting the values obtained in Eqs. (4), (8) into Eq. (9). The results of calcuration are given in Table (3).

Table 3.

Dia. (mm) median	0.1	0.3	0.5	0.7	0.9	1.5	1.9
Mean life (sec)	5.1_6	8.0_6	5.6_5	6.4_2	6.0_6	6.9_9	8.5_9

This table shows that a bubble of diameter 0.1 mm has the shortest mean life, and that of diameter 1.9 mm the longest.

Generally speaking, the larger the diameter of a bubble, the longer the mean life, but there is a certain upper and lower limiting value of the diameter.

Though the life of the bubble of diameter 0.1 mm is only 5 seconds, there is always the bubble of this size (see Fig. 4). It is therefore supposed that such a small bubble is in a very activated state and hence easily coagulates with each other and grows up to a larger one, and when larger ones burst, smaller ones are newly produced.

§4. *Acknowledgement*

The author wishes to express his sincere thanks to Dr. Y. Miyake as well as to Dr. M. Nakano for their discussions on the points dealt with in this paper.

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On the Fluctuation of the Kuroshio Current off Shionomisaki from 1950 to 1952

By J. Masuzawa and T. Nakai

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1. *Preface*

In order to throw light upon the Kuroshio Current System in the Southern Sea of Japan, several oceanographical stations have been investigated on the section south of Shionomisaki (33°25′ N, 135°45′ E.). The investigations were particularly useful for observing such an abnormal state of the Kuroshio Current System as the fluctuation of the main stream axis which had occurred in 1934 to 1945 in the Southern Sea of Japan. (Uda, 1949)

This sectional observation was, therefore, carried out on board a weather ships of the Central Meteorological Observatory about once every twenty days continuously since the summer of 1950. (Fig. 1) From July, 1950 to June, 1951 five oceanographical stations were fixed for observation at the interval of about fifty sea miles on the line ("E-Line") between Shionomisaki and the Southern Fixed Weather Station (29° N, 135° E), but since July, 1951 eight stations have been selected on the line ("G-line") south 200 sea miles off Shionomisaki.

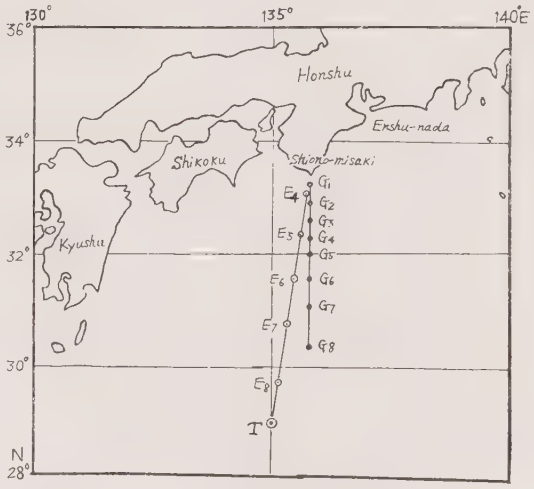

Fig. 1. Oceanographical stations occuppied by Weather Ships of C. M. O. since 1950. T: The Southern Fixed Weather Station.

2. *The mean velocity profile of the Kuroshio off Shionomisaki.*

Fig. 2 shows the distribution of the mean current velocity obtained by dynamic calculations (the reference level is 1000 m in depth) from 33 observations and it is available for seeing the sectional distribution of current velocity. According to Fig. 2 the Kuroshio Current off Shionomisaki approaches the coast of Japan as was recently pointed (Ichiye, 1952, 1953 and Uda, 1949 etc.) and the width of eastward-stream is in average about 120 sea miles. This eastward-stream region is divided into three portions and the coastal portion with the width of 40 sea

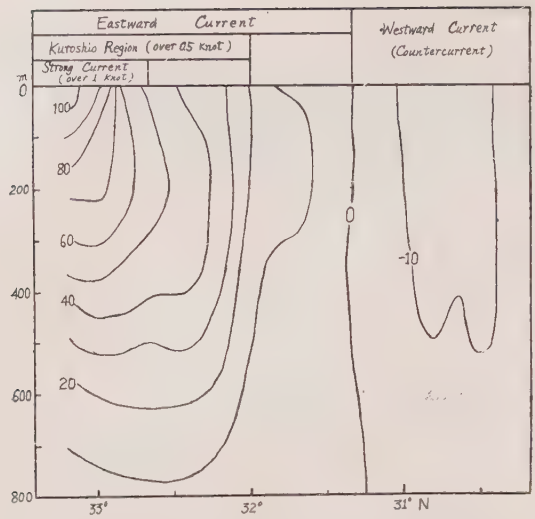

Fig. 2. The sectional distribution of mean current velocity south off Shionomisaki in 1950 to 1952. (positive: eastward, negative: westward, cm/sec)

miles from the coast is the strong current region (>50 cm/sec), while the portion situated next with the width of 40 sea miles has the velocity from 25 to 50 cm/sec. On the southern boundary of the second portion there is a large horizontal shear of current velocity which extends from surface down to the depth of 500～600 m ($0.5 \sim 1.0 \times 10^{-5}$ sec^{-1}). The so-called "Kuroshio" is, therefore, to be defined by this portion which flows with the velocity of 25 cm/sec occupying the thickness of about 500 m. The volume transport through this portion is 39×10^6 m^3/sec amounting to about 80 % of the total eastward flow (44×10^6 m^3/sec). The mean maximum velocity is 100 cm/sec in the surface layer, while the main stream axis may be located at 10～20 sea miles off the coast. To the souh of eastward-stream exists a westward counter current, the centre of which is located at the region about 150 sea miles off the coast with the velocity of 10～20 cm/sec.

3. *Some results obtained by the "E-line" observation from July, 1950 to December, 1951.*

Though the "E-line" observation was not satisfactory for obtaining some exact informations on the sectional structures of the Kuroshio Current, we can see an outline on the variation of the Current by comparing the obtained results with those of four surveys which were carried out in the same period by the Hydrographic Office in the Southern Sea of Japan.

In the period between July and October of 1950, the Kuroshio Current was was situated near the coast off Shionomisaki and the width of eastward stream was only about 80 sea miles accompanied by a fairly remarkable westward counter current, the centre of which was located at the region about 150 sea miles south off the coast. From November, 1950 to March, 1951, the Kuroshio Current approached nearer the coast, but the eastward stream prevailed remarkably on the section not accompanied by any counter currents. Further we could not find during the period any cyclonic eddy such as observed at Enshunada from June to July. From April to May, 1951, the eastward stream became again less dominant and a rather strong counter current appeared off the shore. It is further to be remarked that the velocity distribution off Shionomisaki on 7 May, 1951 much resembled to that on August, 1950. Furthermore, almost the same horizontal velo-

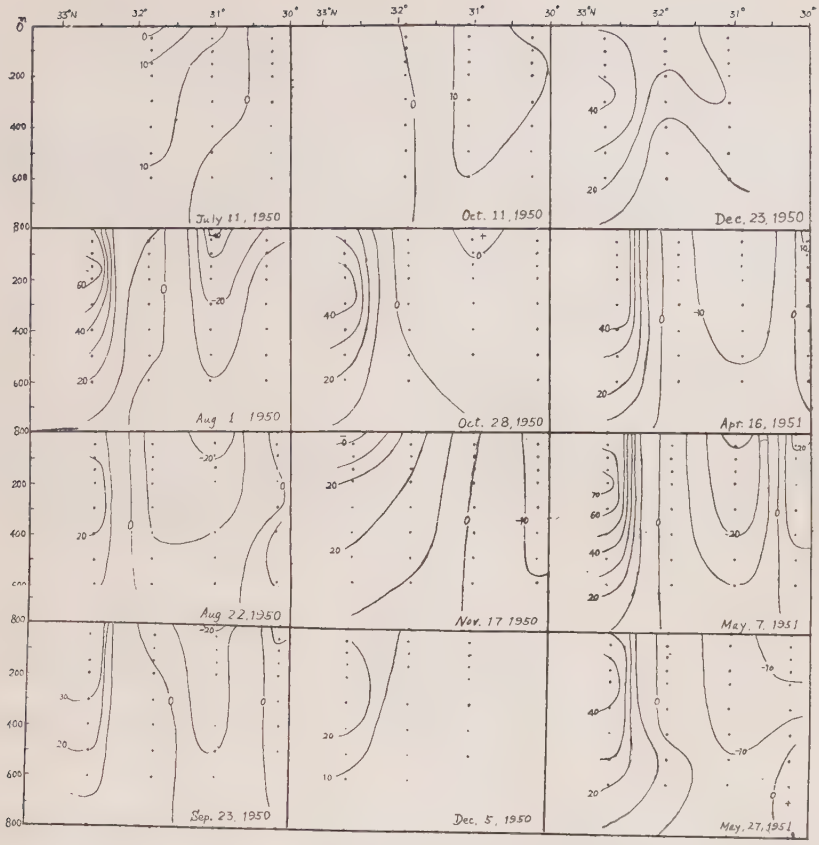

Fig. 3. The sectional distribution of current velcity along the "E-line" south off Shionomisaki from July of 1950 to June of 1951.

city pattern was maintained from June to July, 1950 as well as in May, 1951, if we disregard the existence of cyclonic eddy at Enshunada.

It is concluded that when a cyclonic eddy is in existence at Enshunada to the north of the current, the Kuroshio Current off Shionomisaki approaches nearer the coast accompanied with a distinct counter current which seemingly forms a southern part of an anticyclonic eddy in the south of the Kuroshia Current.

4. *The characteristic travelling of the main axis of the Kuroshio Current in the summer of 1951.*

We are now in a position to give an explanation to the fine structures of the Kuroshio Current in the summer of 1951, because the "G-line" observation has been adopted ever since July, 1951. Judging from the imcomplete observation on 24 July, we could not recognize any significant difference in the sectional distribution of the current velocity comparing it with those in the summer of 1950. But on 14 August, the main axis of the Kuroshio Current was shifted from the coastal region to the position about 80 sea miles off Shionomisaki and a weak counter

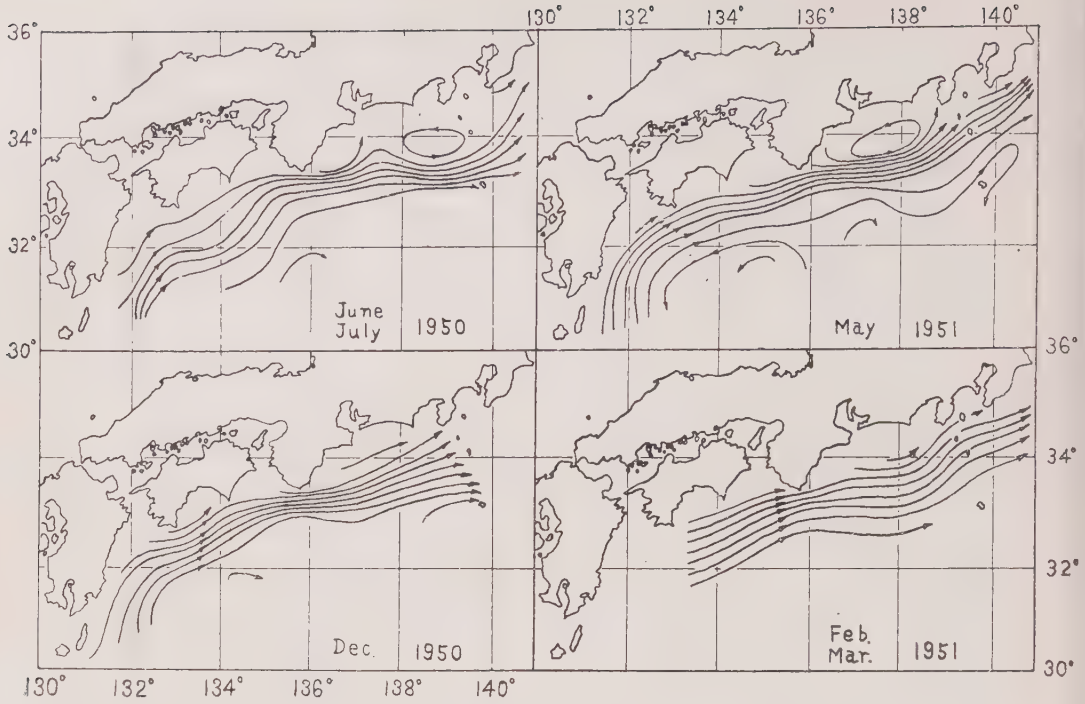

Fig. 4. The Kuroshio Current in the Southern Sea of Japan in 1950 to 1951 obtained by the Hydrographic Office.

current appeared in the region near the coast. The main stream axis was at that time gradually approaching the coast. In other words the axis located on 14 August at the position 80 sea miles off the coast moved to the position 65 sea miles off the coast on 3 September, and further to the position 45 sea miles off the coast on 21 September. The main axis, therefore, approached the coast in average at the rate of about one sea mile per day in this period.

While the warmest water was generally situated in the surface layer at the southern side of the Kuroshio Current, the water of low salinity in the surface layer flowed eastward at the northern side of the Current. The locations of these water masses moved to the north accompanied by a northward movement of the main axis of the Current, and the haline water mass in the subsurface layer (Chlorinity>19.20‰) also projected itself to the north. These remarkable fluctuations of the main stream axis seem to have a connection with the scale and location of the cyclonic eddy at Enshunada. The cyclonic eddy situated at Enshunada in May perhaps moved westward or southwestward to the region off Shionomisaki in the period from the end of July to the begining of August. The main axis off Shionomisaki is, therefore, supposed to have been apart from the coast. Though the water mass of low salinity which had been separated from the coastal fresh water in the surface layer flowed eastward on the northern side of the Kuroshio Current, it may have slipped in the Kuroshio Current from the

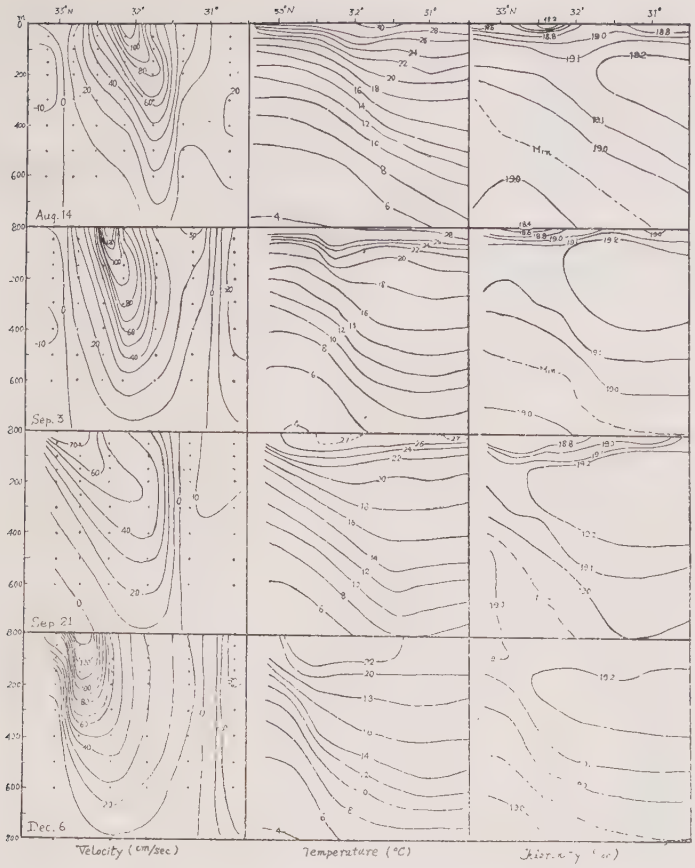

Fig. 5. Sectional distributions of current velocity, water temperature and chlorinity south off Shionomisaki in the summer of 1951.

above mentioned eddy water or the fresh water flowing out from Bungosuido Straight and Kiisuido Straight etc.

Since October the Kuroshio Current off Shionomisaki recovered its normal state as a narrow and strong current flowing near the coast as typically shown in the velocity profile for 6 December.

5. *The seasonal variation of velocity profile in 1952.*

In 1952 one or two sectional distributions of the current velocity off Shionomisaki were obtained in almost every month. It was noticed at once from these result that such characteristics on the velocity distribution as the position and width of the main stream axis, the width and thickness of the eastward-stream and the situations of the counter current etc. in any one observation, were often fairly different from those obtained in the immediately previous observation or from those obtained in the following observation. But in general, the stronger Kuroshio Current flowed near the coast and its main axis remained within 50 sea miles from the coast throughout the year.

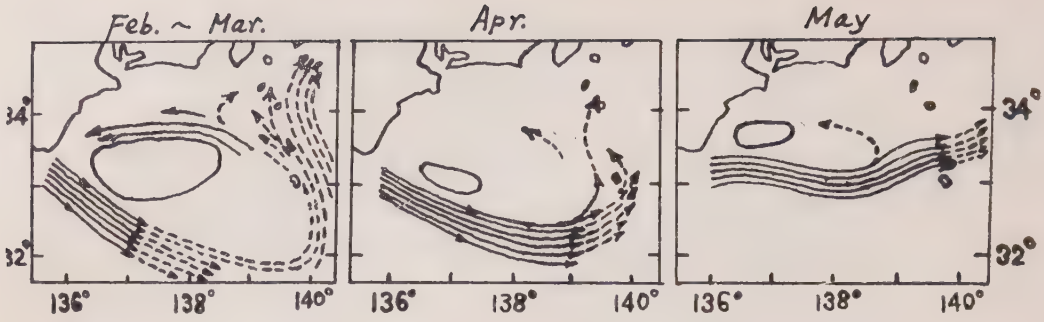

Fig. 6. The Kuroshio Current off Enshunada from February to May in 1952 obtained by the Hydrographic Office.

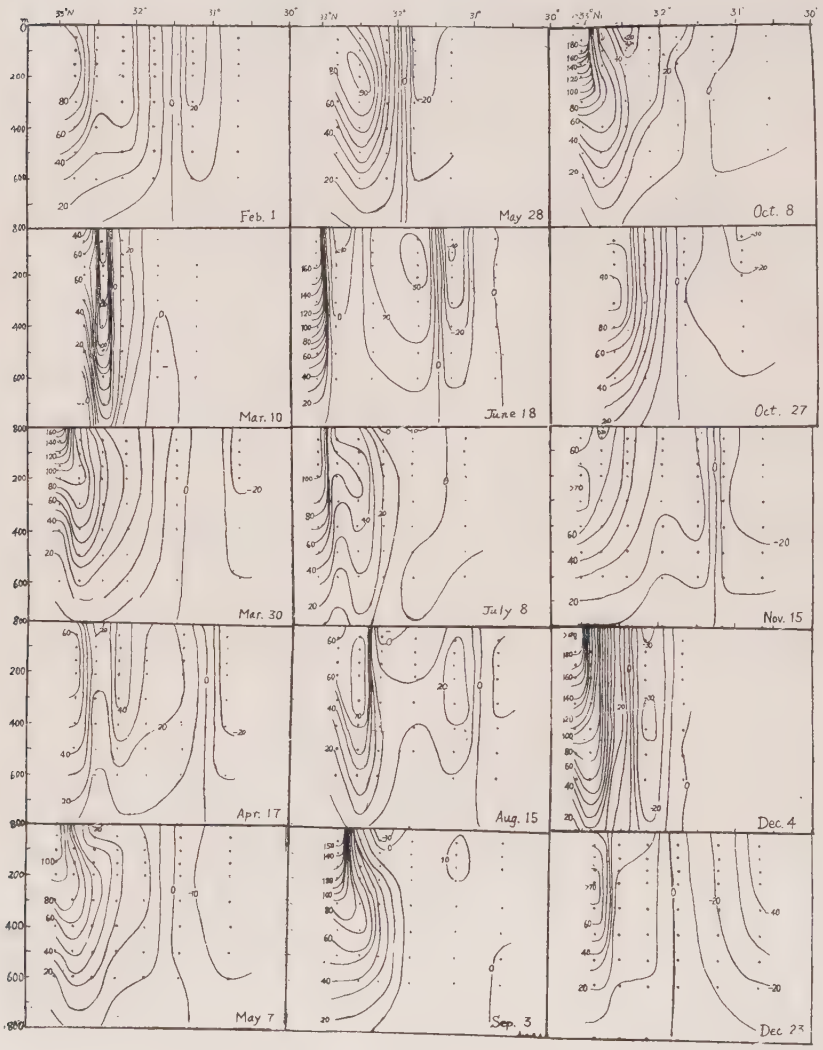

Fig. 7. The seasonal variation of the Kuroshio Current off Shionomisaki in 1952.

In January the strongest current was flowing near the coast maintaining the same condition as at the end of the previous year. But in February, when the Kuroshio Current off Shionomisaki somewhat decreased its velocity, it turned to the southeast after passing off Shionomisaki and went round a large-scale cyclonic eddy at Enshunada. Though that eddy at Enshunada became smaller moving westward during the period from February to May, the velocity distribution off Shionomisaki was ever-changing without showing any general tendency. That is, in the beginning of March, a very strong current flowed about 50 sea miles off the coast with a narrow width. Then, the end of March, it branched out into two bands and decreased its velocity. At the beginning of May it approached the coast and at the end of May it flew fairly apart from the coast losing its width.

Since June, we have been unable to give any systematic explanation of the conditions of the eddy at Enshunada for the lack of general surveys, but the Kuroshio Current off Shionomisaki changed its velocity distribution to the same degree as at the period from January to May. In June, it branched out into two branches and each of them accompanied a distinct counter current in the south. The velocity of the northern branch near the coast was, however, large as it was in March. On 8 July the southern branch was shifted northward to the position about 50 sea miles off the coast, and on 15 August it was the only main stream accompanied by the northern branch near the coast.

After September with the exception of November, the Kuroshio Current has generally flowed near the coast with relatively narrow width. Especially on 4 December, the Kuroshio Current had the width of less than 60 sea miles and the thickness of more than 800 m and its velocity was more than 180 cm/sec at the surface and about 70 cm/sec in the depth of 600 m. Moreover, the relatively strong counter current was in existence in the depth of 1000 m at the region about 80 sea miles off the coast. The horizontal shear of current velocity was, therefore, remarkably large in every depth.

It is worth noticing that from July to September there was in existence a weaker counter current in the surface layer at the region about 80 sea miles off the coast, which transported the salinity-lower water in the surface layer. This water mass was perhaps originating in the coastal fresh water, but we can neither identify the region from which it originates nor give any fuller explanation of its progress.

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New Series, December 1953

On the Hydrographical Conditions Around an Island

By Takashi Ichiye

1. Heretofore the sea adjacent to an island in an open sea has been considered to be a good fishing ground and in view of this point various investigations about oceanographical conditions near the Hachijo Is.[1][2] have been carried out recently, but its fundamental characteristics are still obscure, especially concerning the physical properties of the sea near an island. Here the current conditions and the diffusion of various elements around an isolated island are theoretically treated, in order to give some preliminary guiding ideas which will probably be of some use in attacking the similar problems in future.

2. It has been generally accepted that the upwelling current takes place behind an island and supplies nutrient bottom waters and the simple explanation about this problem will be given here. As a hydrodynamic problem, the fluid motion around an obstacle in a uniform current has been studied both theoretically and experimentally,[3] but the results are not immediately applicable to the situation around an island, since in the latter case, the effect of Coriolis force, the existence of free surface, the vertical structure of current and water density and bottom influence should be taken into account. Further, the coefficient of eddy viscosity is quite different in its magnitude and properties from ordinary viscosity. It is therefore almost impossible to solve such a problem mathematically. However as indicated by C.—G. Rossby[4] for the sufficient deep current, the Coriolian pressure gradient offsets the deflecting force and by introducing a simple model of vertical density stratification, we can further estimate the current conditions from the results of non-rotating current around an obstacle. As seen from the results of hydrodynamical investigations, the current conditions mainly change with Reynolds' number, but in the current behind an obstacle the velocity generally decreases due to the vortex or turbulence in the wake. Therefore when we take Reid's model of density distribution[5] and put the velocity $u=u_0-u_1$, where u_0 is undisturbed current and u_1 the disturbed motion by an island, then from the relation between the Coriolian pressure gradient and current velocity we have

$$\frac{1}{\rho}\frac{\partial p}{\partial y} = 2\Delta\rho \cdot g \frac{\partial h}{\partial y} = -\lambda u = -\lambda(u_0 - u_1)$$

at the upper homogeneous layer.

By integrating this equation we have

$$h = -\frac{\lambda}{2\Delta\rho \cdot g}\{u_0(y-y_0) + \int_y^{y_1} u_1 dy\}$$

where y_0 is the left boundary of the undisturbed current and we can assume that the coast exists at $y=y_0$ without loss of generality and y_1 is the left boundary of the wake. Since $u_1>0$, it is seen that h decreases within the wake. We next take the numerical constants corresponding to the observed conditions in ocean currents such as $\Delta\rho=4\cdot10^{-3}$, $\lambda=0.8\cdot10^{-4}$. Further we put $u_0=10^2$ (cm/sec) $y_0=50$ (Km) $y_1=10$ (Km) and at the region $y_1>y>-y_1$ we assume the dead water region. Then the decrease of the depth h is 10 m at $y=-y_1$. The schematical representation of the vertical distributions of density is shown in Fig. 1, where the density in situ is shown for the vertical section, from which we can see that at the right half of the current the ascending of the isopicnic lines of $\sigma_t=26.5$, 26.75 attains 30~40 m. In the neighbourhood of the island, the more detailed distributions of Coriolian pressure are given by use of the velocity distributions obtained from solutions of Oseen-Lamb's approximate equations of motion[6] for the current around a circular cylinder. Indeed from the relations

$$2\Delta\rho\cdot g\frac{\partial h}{\partial x}=\frac{\lambda c}{4}(r^2-a^2)\frac{\partial^2}{\partial x\partial y}\log r,$$

$$2\Delta\rho\cdot g\frac{\partial h}{\partial y}=-\frac{\lambda c}{2}\left\{r-\frac{1}{2}+\log\frac{1}{2}kr+\frac{1}{2}(r^2-a^2)\frac{\partial^2}{\partial x^2}\log r\right\}-\lambda u_0,$$

$$c=2u_0\left(\frac{1}{2}-\gamma-\log\frac{1}{2}ka\right),$$

we have

$$h=-\frac{\lambda u_0 y}{2\Delta\rho\cdot g}\left\{1-\left(1-\log\frac{1}{2}kr-\gamma-a^2/2r^2\right)\Big/\left(\frac{1}{2}-\gamma-\log\frac{1}{2}ka\right)\right\}+\text{const.}$$

The numerical result is shown in Fig. 2 by taking $ka=u_0a/2\nu=0.5$, where only the variable part of the above relation is computed, which indicates that in the right half of the wake region behind the island the depth h decreases as compared with the case of undisturbed current. The above velocity distributions are valid only for small values of Reynolds' number u_0a/ν and for the region near the island. However general properties are also seen from this figure.

When the wake behind the island is turbulent, the velocity distribution is given by[3]

$$u=u_0-U,\quad U=u_0f(\eta)/x^{1/2},\quad f=\frac{\eta_0^3}{18a_1}(1-\xi^{3/2})^2,\quad \eta=y/x^{1/2},\quad \xi=\eta/\eta_0,$$

where a_1 and η_0 are constants and the edge of the wake is given by $y_0=\eta_0x^{1/2}$. The functional form of f is obtained from the equation of continuity $\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0$, when we assume non-divergent flow.

Since $$\frac{\partial v}{\partial y}=-\partial U/\partial x=-Au_0(4\xi^{3/2}-1)(\xi^{3/2}-1)x^{-3/2},\quad A=\eta_0^3/36a_1,$$

and at $y=y_0$, $-y_0$ $v=0$, we have

$$v=-u_0A\eta_0\xi(1-\xi^{3/2})^2x^{-1/2}, \qquad (1>\xi>0)$$

and

$$h=-\frac{\lambda}{2\Delta\rho\cdot g}\left\{u_0y-\frac{u_0}{2}\eta_0A\xi\left(1-\frac{4}{5}\xi^{3/2}+\frac{1}{4}\xi^3\right)\right\}+\text{const.}$$

Therefore if we consider that the density stratification at the left side of the outer region of the wake is undisturbed by the presence of the island, the ascending of isopicnals within the wake is concluded as the above simple model and this effect has a similarity within different sections of the wake. Further as seen from the form of v, converging current flows within the wake region, which also seems to contribute to make the region behind the island a good fishing ground, though the above expressions for the velocity distributions are only valid far down from the obstacle. The above relations are deduced from the assumption of non-divergent current, but in practical case

$$\frac{\partial u}{\partial x}=-\frac{\partial U}{\partial x}>0 \quad \text{for} \quad -\left(\frac{1}{4}\right)^{2/3}<\xi<\left(\frac{1}{4}\right)^{2/3}$$

and some parts of the divergence in u is balanced by the vertical current and thus the upwelling is expected to occur near the central line.

3. In practical examples, the current near an island is not so simple as a hydrodynamical model, but the general features have a remarkable analogy with the latter and this is probably due to the fact that the observed current condition in the ocean is determined only statistically or it is the mean current with time and space, therefore the effect of horizontal eddy viscosity becomes similar to that of molecular viscosity on the hydrodynamical model. When we see the observed current conditions near Hachijo Is.[1] from such stand point of view and compare with the model experiments[6], the current patterns of the former is seen to have similarity to those of models for the Reynolds' number of about 10～20, since the convergence of stream lineas behind the island occured at about 2～3 times of the radius of the island and the region of stagnation current is limited only to such an extent within these stream lines and the countour of the island. Thus the order of the horizontal eddy viscosity is about 10^5～10^7, since U_0～10^2 (cm/sec) a～3～7 (Km) (the radius of the island).

Next we determine the horizontal eddy viscosity from the observed current around Hachijo Is. which was reported by Dr. M. Uda. For this purpose, we assume that the paths of current floats follow the stream line and the velocity fluctuations of the floats along a stream line are caused by the eddy motion. Then the coefficient of horizontal eddy viscosity can be put as[3]

$$A=\sqrt{v'^2}\,l\,,$$

where the mean square value of the velocity fluctuations v'^2 is considered to be given by $\frac{1}{n}\sum(v-v_0)^2$ or the mean square of the velocity fluctuations along the stream line and further $l=\sqrt{v'^2}\int_0^T{}^1R_\xi d\xi$, where R_ξ is the correlation between v at time T and v at time $T-\xi$, or in the practical application we can take it as

the serial correlation coefficients of current velocity determined by the positions of the flort at each hour interval. By use of these formula, we can compute R_ξ and $\overline{v'^2}$ from the observed current and the results of such calculation are given as follows

$$\overline{v'^2} = 174\,(\mathrm{cm^2/sec^2})$$

$R_1=0.693$ $R_2=0.725$ $R_3=0.595$ $R_4=0.308$ $R_5=0.083$ $R_6=-0.227$,
(R_n means the correlation between $v(T)$ and $v(T)$ and $v(T+n)$, where n is given in hours.),

where each value is the mean of four calculations carried out for different stream lines. As seen from the values of R_n the correlation almost vanishes after 4 or 5 hours and from the formula $A=\overline{v'^2}\int_0^{T_1} R_\xi d_\xi$, we obtain

$$A=8.4\times10^5\ (\mathrm{cm^2/sec}) \quad (T_1=5\ \mathrm{hrs})$$
$$A=6.1\times10^5\ (\quad ''\quad) \quad (T_1=4\ \mathrm{hrs})$$

by numerical integration of the integral about R_ξ.

By comparing the order of the horizontal eddy viscosity thus obtained with the above conclusion, the agreement of the current patterns between the large scale current around the island and the small scale one near the hydrodynamical model seems to be not unreasonable.

4. The problem of the diffusion of the coastal waters discharged from an isolated island is more complicated, since the diffusion coefficient and current conditions are both difficult to be determined definitely, but the general trend is obtained by considering the mean condition and such example is given below, by computing the diffusing equation

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=K\left(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}\right), \qquad (1)$$

under the suitable boundary conditions and comparing the solution with the observed distributions of chemical components near Hachijo Is. The solutions of the eq. (1) is obtained analytically when the current velocity u, v is given for the potential flow[3], but it is generally quite complicated for the viscous flow. Therefore we solve this equation for the circular island, the radius of which is given by $r=a$, numerically by Thom's method[7] under the boundary condition that at $r=a$, $T=1$. For this purpose we assume that the current is given by $u=\partial\psi/\partial y$ and $v=-\partial\psi/\partial x$ and we take the stream function ψ as that computed by him numerically under the condition: undisturbed velocity=6.25, cylinder diameter=6.25, coefficient of kinematic viscosity=10 or for the Reynolds' number $R=2au_0/A=10$. The method is as follows: First we transform $x-y$ plane into $\xi-\eta$ plane, which is covered by the stream lines and equipotential flow surrounding a circular cylinder, where

$$\xi=\left(r+\frac{a^2}{r}\right)\cos\theta, \qquad \eta=\left(r-\frac{a^2}{r}\right)\sin\theta,$$

and divide the $\xi-\eta$ plane into small squares surrounded by equi-ξ lines and equi-η lines, then we obtain from the diffusion equation (1) the next relation

$$T_C=T_M-\frac{1}{16K}\{(a-c)(B-D)+(b-d)(C-A)\}, \qquad (2)$$

where A, B, C, D are corner values of ψ and a, b, c, d, are the corresponding values of T. T_M is the mean value of the corner values and T_C is the center value of the small square. Next we assume the adequate initial value of T for each corner and compute the center value from the above relation, then they are used again for the corner values and the process are repeated, till the values all over the field are settled. The settling of the numerical solutions should be the more rapid, if the initially assumed distributions are the more similar to the real solution, therefore it is most desirable to take the initial value as near the true solution as possible. For this purpose we use the Boussinesq's solution for the diffusion in the potential flow

$$T=\sqrt{\frac{1}{2V}}\int_{-\infty}^{\infty}F(\xi-n\eta^2/\nu^2)e^{-1/2\nu^2}d\nu \qquad (2n=u_0/K) \qquad (3)$$

where the functional form of $F(\xi)$ is determined by the boundary condition at the boundary value of T on the cylinder and the value of T on the line

$$y=0\ (x>a,\ x<-a), \qquad \text{since} \qquad T_{(\eta=0)}=F(\xi).$$

This solution is only the approximate one even for the potential flow and King's solution is analytically exact[8] but the latter is more complicated for the numerical computation, because it is necessary to solve the integral equation for the problem of the type such as the value of T is prescribed over the boundary. Further even the analytically exact solution of the latter is unsatisfactory, since it involves the discontinuities of T immediate to the boundary, thus the above solution[3] is used here. Only the Boussinesq's original solution assumed that the value of F is given as

$$F=1\,(-a<\xi<a)=0 \quad (-a>\xi,\ a<\xi) \qquad \text{or}$$

$$T=\Phi\left(\sqrt[4]{\frac{n}{2(\xi-2a)}}\eta\right)-\Phi\left(\sqrt[4]{\frac{n}{2(\xi+2a)}}\eta\right) \qquad (\xi>2a)$$

$$T=1-\Phi\left(\sqrt{\frac{n}{2(\xi+2a)}}\eta\right) \qquad (0<\xi<2a),$$

where Φ means an error function, therefore it also indicates the discontinuities of T at the rear and foward stagnation point. In the real conditions such discontinuities are impossible and we should replace it with more reasonable distributions. For this the boundary layer theory gives the exact solution for the distributions of T near the foward staganation point, which is[9]

$$T=1-\theta(\mu),$$

where

$$\theta=\alpha_3(\sigma)\Big[\int_0^{\mu}\exp\Big(-\sigma\int_0^{\mu}f\,du\Big)\Big]du,$$

$$\mu=(4/R)^{1/2}\,x+a\ ,\quad R=\frac{2au_0}{A}\ ,\quad \sigma=A/K\ \text{(Prandtl number)},$$

and $f(\mu)$ represents the boundary layer function defined for the velocity distributions within the boundary layer. It is reasonable to take this distribution near the foward stagnation point but for the rear stagnation point the current condition is quite variable for the difierent values of Reynolds' number, thus such simple formula is not applicable. However, for small Reynolds' number as assumed in the present case the current conditions near the rear stagnation point are not so different from those near the foward as seen from the stream lines comput ed by Thom, since there the vortex pair is not formed. Thus we use the same distribution of T near the rear stagnation point, though we take $\mu=(4/5R)^{1/2}(x-a)$, since the velocity outside the rear stagnation boundary layer can be estimated about 1/5 of that for the foward from his stream lines and we follow the same process to determine the coefficient of μ as the case about the distribution of T near the foward stagnaton point. In the practical computation we put $\sigma=1$ and take the function $F(\xi)$ corresponding to these values outside the region $-a<\xi<a$ and further we compute T by the eq. (3) numerically. Such process of the determination of the initial distributions seems to reduce the laborious numerical computation, for in Fig. 3 the comparison of the initial distributions of T near the foward and rear stagnation point and those of the final results are shown and from this we can see that near the foward stagnation point the initial values are almost the same as the final ones, though near the rear stagnation point the final results show somewhat larger value than the initially assumed ones. The disagreement of the initial theoretical distributions of T near the rear stagnation point is not unexpected as stated above and the final values seem to correspond to the theoretical values for the case that the numerical constant of μ is taken as $(2/10\,R)^{1/2}$ or when we take the velocity outside the rear boundary layer about two times of the practical velocity and it is not so unreasonable to explain this difference in the theoretical and practical distributions as due to the fact that near the foward stagnation point the current flows to the source region, whereas at the rear it flows away from the source. The final results of the computations of the distribution of T over the whole region around a circular cylinder are shown in Fig. 4 with the stream lines computed by Thom. It indicates that the diffusion behind a cylinder is the most conspicuous and that in the direction transverse to the mean current is larger than in the foward region. It is expected that the diffusion near the line $y=0$ behind the cylinder should be reduced more when the Reynolds' number increases or the Prandtl number increases and thus the maximum diffusion becomes more conspicuous along two directions behind the cylinder, or two tails of the distribution curves behind the cylinders elongate to the larger distance. When we compare this figure with the distributions of some chemical components near Hachijo Is., especially Fig. 7 (Cl.) Fig. 8 (nitrate-

N) of the paper (2), we can see the observed distributions have some analogy with theoretical ones, especially in regards to the point that they have two projected tongue-like distribution curve behind the island. Further when we assume that Cl. at the coast of the island is 19.19‰ and that of the distant region is 19.29‰ from the observed data and the nitrite-N of the former is 40 (μg at/litre), that of the latter is 0, we can compute the values of T for Cl. and Nitrite-N and the relation of these relative concentrations with the distance from the island are plotted for the region near the rear stagnation point in Fig. 3, for comparison with the theoretical distributions, from which we can also assure the agreement between the observed and theoretical distributions even quantitatively.

5. Another example which seems to give some clues to the property of the diffusion condition behind an island is given in Fig. 5, where the remarkable boundary line between clear waters behind the island (colour of sea is 4～5) and the muddy waters around them discharged from the river after the heavy flood caused by rainfalls in Wakayama Pref. on Jul. 19th and 20th, 1953. The observation was carried out on 21st and the location of the boundary is determined only by visual observation but at two points outer and inner regions of this boundary the values of surface Cl. and wind data are obtained and further the surface drift were observed near the coast, which are also shown in the figure. (After the obs. by Mr. S. Moriyasu). Unfortunately more close observations near the island were not carried out and thus the detailed analysis is impossible but, since the clear waters behind the island indicate that the surrounding muddy waters are not transported to such region, we can see that the diffusion in this case are quite different from those near Hachijo Is. and they are more similar to the turbulent wake or the shadow region seems to extend to much greater distance. The reasons of such difference are considered as follows:

(1) The diffusion did not attained to the steady state yet and the vorticity layer along the boundary of the wake was not fully diffused.

(2) The wake became turbulent due to the small value of the eddy horizontal viscosity, since the space and time interval over which the mean is taken for obtaining the current and diffusion state are much smaller than the case near Hachijo Is. For instance, because $u_0 \fallingdotseq 30$ (cm/sec) $d=0.7\times10^5$ (cm) it is necessary that $A<10^3$ (cm^2/sec), for the turbulent wake is formed for Reynolds' number[10] above 5×10^3 behind a circular cylinder. In other words the effective viscosity seems to be smaller, since the steady state is not reached or the time interval over which the mean is taken is small.

(3) The clearness of the boundary seems to be due to the fact that the fine silts which are attributed to for the muddy colour descend more rapidly in the pure waters, whereas in the land waters spreading over the sea waters they suspends relatively long time at the surface due to the large vertical stability there. Although the waters of muddy colour are not of purely land waters and those of clear colour are also mixed with them, the contents of such silts in two waters

should be quite different and this fact indicate that the boundary line probably represents the critical case for the relation between the descending velocity of the fine particles and the vertical stability. Further analysis shall be given in future, when the detailed data for such conditions are obtained.

Lastly the author wishes to express his thanks to Dr. M. Nakano, Dr. Y. Miyake for their kind advice and also to Dr. K. Hidaka, Dr. K. Wadati, Dr. K. Suda, Dr. M. Uda, Dr. Y. Kawabata, Dr. K. Terada and Dr. Y. Takenouchi for their encouragement. Further he is indebted to the Special Committee on Marine Resources in the UNESCO Committee of Science Council of Japan for financial aids.

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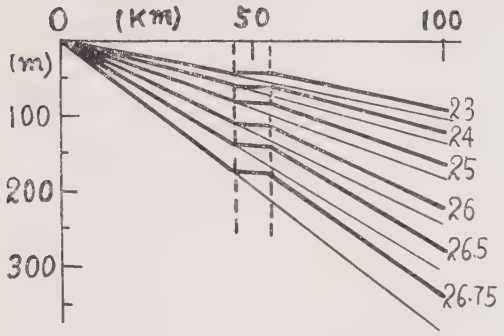

Fig. 1. Schmatical representation of isopicnic surfaces behind an island in a uniform ocean current. (Thin lines: σ_t surfaces for an undisturbed current. Thick lines: those under the assumption of the dead water region behind an island.)

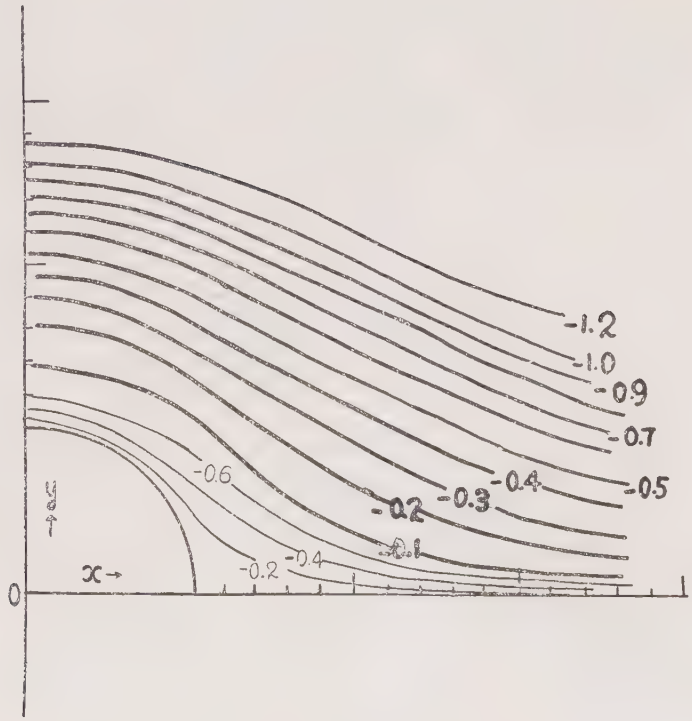

Fig. 2. Relative topography of the depth of the surface homogeneous layer near a circular cylinder in Oseen-Lamb's motion. (The unit is taken as $\lambda u_0/2\Delta\rho \cdot g$. For the domain $y<0$, the anti-symmetric distribution is obtained.

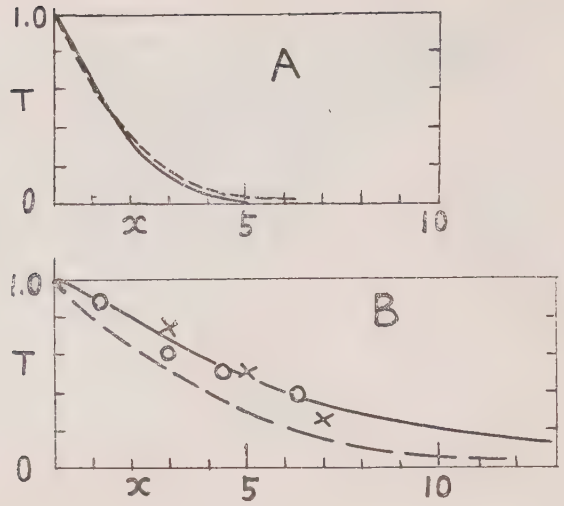

Fig. 3. The initial and final distributions of concentration near the foward and rear stagnation points of a cylinder, the radius of which is 5. (Full lines represent final results, broken lines initial ones. (A) is for the foward and (B) for the rear stagnation point. In B the circles indicate the observed concentrations of Cl. and the crosses those of nitrite-N, both of which are computed from the observations near Hachijo Is. as reported by Dr. Y. Miyake.)

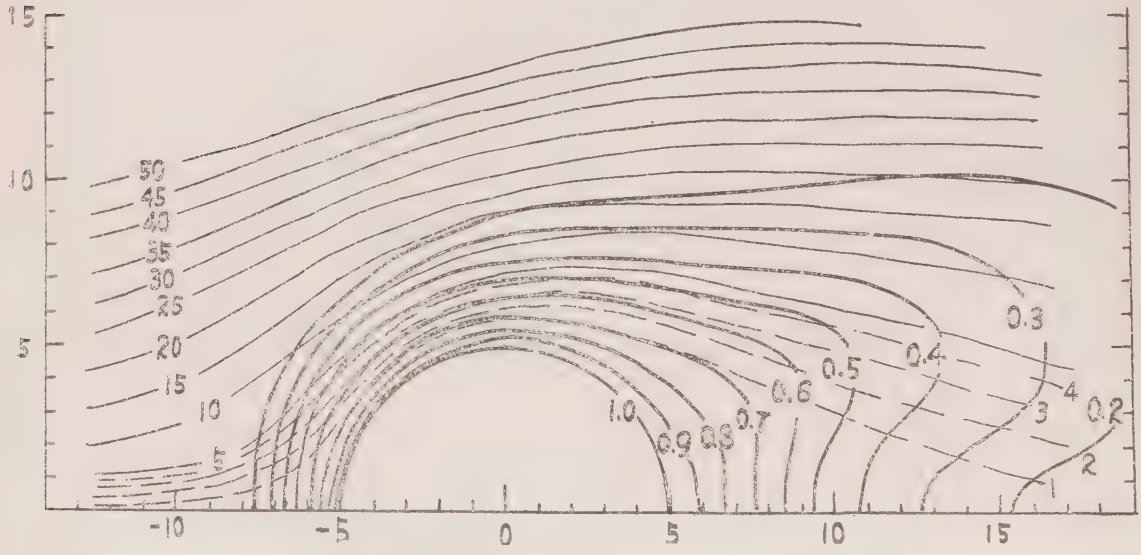

Fig. 4. The distributions of concentrations around a circular cylinder in a viscous flow (thick lines) computed by Thom's method and the stream lines of the flow given by Thom. (Thin lines) (Reynolds' number $2au_0/A=10$, Prandtl' number $A/K=1$)

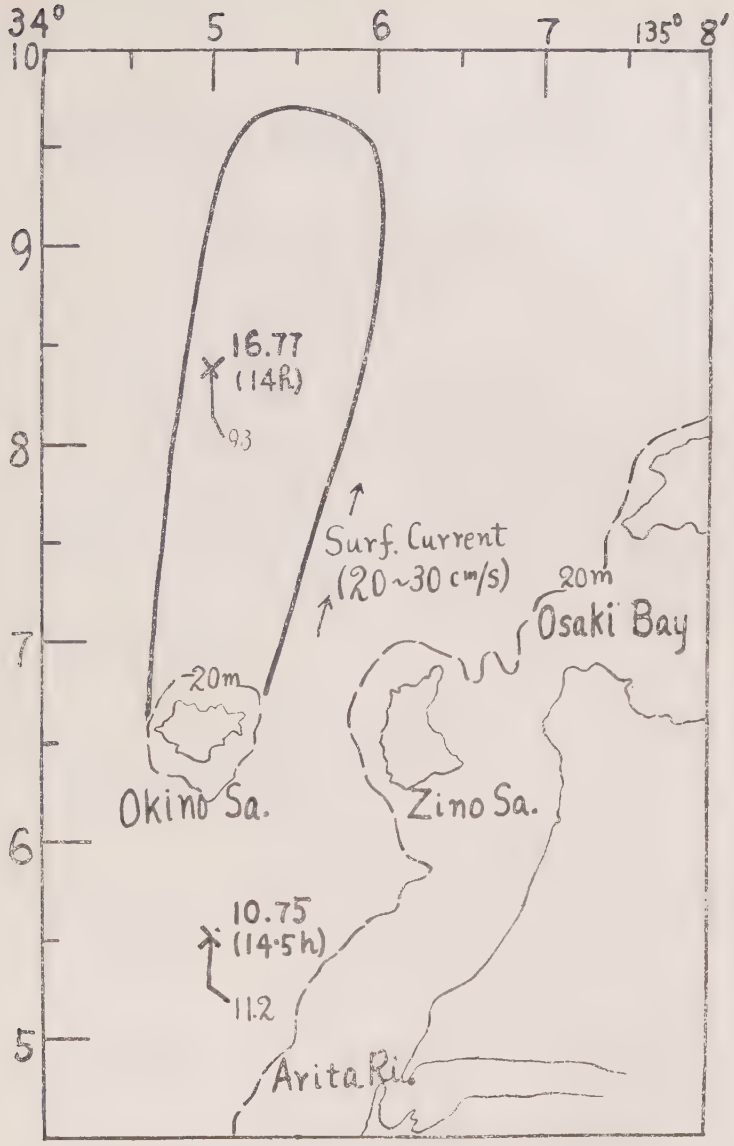

Fig. 5. Location of the conspicuous boundary between the clear waters and the muddy waters surrounding them (the thick line), on the basis of obs. 21st, Jul. 1953 in Kii-Channel. (Crosses indicates the surface observation stations, where the figures are Cl. in % and observation time. The arrows show the wind direction, the figures near by are its velocity).

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Determination of Selenium in Sea-Water

By Masayoshi Ishibashi, Tsunenobu Shigematsu,
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The value obtained as an amount of selenium in sea-water by Goldschmidt et. al.—4γ/L—is on the whole acknowledged and it does not seem any further studies on it have been performed subsequently.

The authors determined the amount of selenium in the sea-water sampled in the offing of Shirahama, Wakayama Prefecture, Japan, and obtained the almost same results as those by the aforesaid workers.

COLORIMETRIC DETERMINATION OF SELENIUM

At present the following methods can be used for the colorimetric determination of trace of selenium; pyrrole method, codeine method, and reduction method by rhodanate or thiourea. (The last one makes use of red colour of reduced colloidal metallic selenium.)

The authors studied on the colorimetric procedure by thiourea and established the conditions necessary and satisfactory to obtain accurate results.

A standard selenium solution was prepared dissolving SeO_2 into proper amounts of water to adjust the concentration to 0.100 mg/ml.

The selenium solution was acidified with 2~3 ml of HCl, diluted to approximately 40 ml, and then to this solution 5 ml of 10% thiourea solution was added to yield red colour by colloid al selenium. After the adjustment of the volume of the solution to 50 ml, the red colour of the solution obtained was colorimetrically measured.

In this case the measurement should be carried out after 5 to 10 minutes, for, after long standing, it is sometimes disturbed by the precipitation of the colloidal selenium.

Pulfrich photometer was used for this measurement; the cell 5 cm, being the filter, S_{47}.

It was found that through this procedure 50 to 300 γ of selenium can be determined within 3% error.

The results obtained are shown in Table 1.

Table 1.

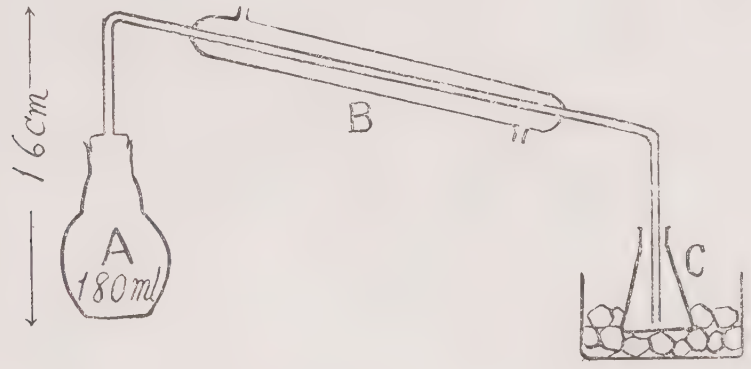
Se Taken	Se Found	Error
100 γ	100.6 γ	0.6 γ
150	145.3	4.7
200	198.1	1.9
250	253.8	3.8
300	306.4	6.4

At the same time it was also found that the measurement are interfered by the presence of Cu, Te, HNO_3 or plenty of Fe.

SEPARATION OF Se BY DISTILLATION

For the separation of Se was used such a distillation apparatus as shown in Fig. 1. Into flask A was put 10~20 ml of the sample solution, 20 ml of 47% HBr and 40 ml of H_2SO_4 (1 : 1). The end of cooler B was touched at the surface of water (5 ml) in adoptor C, which was cooled by ice. The juncture of A and B was made air-tight by grinding. A little amount of conc. H_2SO_4 was used as a lubricant for this juncture.

Fig. 1



The distillation was carried out adjusting the temperature in order that 25~30 ml was distilled for 15 minutes.

1 ml of 1% phenol aqueous solution was added to the distillate. Using this solution, the selenium amount was determined by means of the aforesaid procedure.

The recovery efficiency of selenium by the distillation was investigated, both in case of the sample solution alone and of the presence of other ions, using a definite amount of selenium. The results are shown in Table 2.

In case of selenium alone or of the co-presence of 10~20 mg of As, more than 96% of the selenium was recovered and no interference by As was observed. The

presence of iron, however, made the distillation of selenium too incomplete and gave only poor recovery in this consequence.

This is the reason why iron must be removed before the distillation of selenium if iron is present with selenium.

Table 2.

Se Taken	Ions Co-present	Se Found	Recovery Efficiency
200 γ		194.3 γ	97.1%
300		289.3	96-4
300	200 mg Fe	190.6	63.5
300	300 mg Fe	——	20
300	15 mg As	290.0	96.6

CONCENTRATION OF SELENIUM IN SEA-WATER

The selenium content is so little that it is difficult to distill the selenium alone from sea-water as it is, and then determine its amount colorimetrically.

In order to adequately concentrate the selenium in sea-water, the authors utilized the co-precipitation method as follows; At first, using $Fe(OH)_3$ as a carrier the selenium was thrown down with it. Then the selenium was again carried down, from its acidified solution, with As_2S_3 in order to eliminate the interference from iron in separation by distillation and colorimetric determination of selenium.

The co-precipitation of selenium with ferric hydroxide was comparatively incomplete when the amount of iron was little, whereas it became almost complete in case more than a certain amount of iron is used. On the other hand, the co-precipitation of it with arsenous sulfide was not particularly influenced by the amount of As being comsaratively insufficient.

As the first step, the authors investigated, as follows, the recovery efficiency of selenium through this concentration procedure by the co-precipitation using artificial sea-water; to artificial sea-water was added a certain amount of Se as selenous acid and 200 to 300 mg of iron as $FeCl_3$ solution, and the solution was thoroughly mixed. After addition of 10 ml of NH_4OH under stirring, the solution was allowed to stand for two to three days to completely precipitate $Fe(OH)_3$. The precipitate was filtered and dissolved with as small amount of hot H_2SO_4 (1:4) as possible. Then the solution was neutralized with NH_4OH, acidified by adding 3 ml of H_2SO_4 (1:4), and diluted to 50 70 ml. A certain amount of As was added to this solution. Furthermore, after addition of 20 ml of saturated H_2S water, the solution was once more allowed to stand overnight to precipitate As_2S_3. The precipitate was filtered through a glass-filter, dissolved with 20 ml of hot HNO_3, and evaporated to dryness on a water-bath. The residue was dissolved into 20 ml of 47% HBr. 40 ml of H_2SO_3 (1:1) was added to this solution. In the next place,

as noted in the preceding paragraph, the selenium was distilled from the solution. After addition of 1 ml of HCl, the filtrate was adjusted to 50 ml (total volume), and subjected to the colorimetric determination of Se by thiourea method.

The results are shown in Table 3. The table makes it clear that the recovery efficiency was from 70 to 80%.

The mark "a" in the table means that in these experiments the procedure for the coprecipitation with $Fe(OH)_3$ was eliminated and only the co-precipitation efficiency of As_2S_3 was investigated under the circumstance of co-presence of Fe, As, and Se when 20 ml of H_2S water was added to yield As_2S_3. Thus, in the comparison of these two kinds of experiments, it would be readily recognized that the coprecipitation efficiency of $Fe(OH)_3$ was nearly complete.

Table 3.

Artificial Sea-Water	Se Added	Fe Added	As Added	Se Found	Recovery of Se
1 L	0 γ	200 mg	10 mg	0 γ	——
1	200	200	10	164	82%
2	300	200	10	210	70
5	200	200	10	150	75
5	300	300	10	218	79
a	200	200	10	178	89
a	300	200	10	246	82
a	300	300	10	224	75
a	300	200	50	210	70

DETERMINATION OF SELENIUM IN SEA-WATER

The analysis was carried out of the sea-water sampled at the offshore of Shirahama, Wakayama Prefecture. 700 mg of ferric iron was added to 20 L of the sea-water. Then 20 ml of NH_4OH was added dropwise under constant stirring to throw down $Fe(OH)_3$.

The following procedure was performed as already explained: the precipitate was dissolved with H_2SO_4, and 15 mg of As^{+++} was added. After the precipipitated As_2S_3 was filtered by H_2S, it was dissolved with HNO_3, and the solution was evaporated to dryness. The residue was dissolved with HBr water and the selenium distilled for separation. The amount of Se was colorimetrically determined by use of thiourea. The results obtained are shown in Table 4.

Table 4.

Sea-Water Taken	Se Found	Se Calculated	Se γ/L
20 L	88.0 γ	110～126 γ	5.6～6.3
10 (+50 γ Se)	78.2	98～112	4.8～6.2
10 (+70 γ Se)	79.8	100～114	3.0～4.4

The sea-water, whose temperature was 7°C, density 1.026 (at 12°C), and chlorinity 18.96‰, was sampled on Dec. 20, 1951, at the offshore of Shirahama, Wakayame Prefecture, Japan.

As seen from Table 4, the selenium content of the smapled sea-water is believed to be 4 to 6 γ/L, being in average 5 γ/L. This value is in good accordance with that obtained by Goldschmidt et al.

The authors with to thank Dr. T. Tokioka, of the Seto Marine Research Institute of Kyoto University, for his help in sampling the sea-water.

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Copper and Zinc in Pacific Waters I

By Yoshimi Morita

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The amount of copper and zinc in the sea water has been repeatedly determined by many investigators. However, most of the data so far obtained are unfortunately unreliable, partly owing to defects in the methods and their application and partly owing to contamination of the metallic sampler used and often to insufficient care in handling the collected samples.

The author previously developed a procedure in which such defects and contamination could be avoided and examined 21 samples of the surface waters from Tokyo Bay and Ise Bay[1].

Although these waters looked more or less contaminated by land drainage, the amount of copper and zinc were found far less than ever reported. It was also noticed that the amount decreased from the head of the bay towards its mouth, seemingly with decreasing contamination.

It is natural to expect that the waters free from the effect of land will give smallest values and the copper value will drop probably below 1 μg/l.

The study was thus extended along this line. First, the surface waters of the "Kuroshio" area were examined in May, 1951, on board No. 5 Kaiyo-maru, a surveying boat of the Hydrographic Office, Maritime Safety Agency, while at the second time the vertical distribution was determined in Sagami Bay and Suruga Bay in February, 1953, on board Umitaka-maru of the Tokyo University of Fisheries.

For collecting surface waters, a glass sampler was used which was in advance thoroughly cleaned with special care, while for deep water sampling, an Eckmann type sampler coated with acrylic resin was devised, taking into consideration that trials by the previous investigators, who used a metallic sampler, failed to obtain a satisfactory result probably due to contamination from the instrument. The determination was carried out by mixed-colour colorimetric titration with dithizone[2].

The results, as shown in Tables 1 and 2, show that

Table 1.

Copper and zinc in the surface waters from the "Kuroshio" area.

	Location		Date	Cu μg/l	Zn μg/l
St. 1	34°06′N,	138°09′E	May 1, 1951	0.5	1.5
St. 2	33°40′N,	138°11′E	May 2, 1951	0.6	1.3
St. 3	33°16.5′N,	138°13.5′E	May 2, 1951	0.7	—

Table 2.

Vertical distribution of copper and zinc.

Sagami Bay			Suruga Bay		
Location: Central part of the bay 35°03.8′ N, 139°21.8′ E			Location: 35°00′ N, 138°39.1′ E		
Date: Feb. 12, 1953			Date: Feb. 15, 1953		
Depth m	Cu μg/l	Zn μg/l	Depth m	Cu μg/l	Zn μg/l
0	0.9	2.2	0	0.8	2.3
50	0.6	1.8	50	—	—
80	0.3	2.0	80	—	—
100	—	—	100	0.6	1.8
200	0.8	2.4	200	0.6	1.9
400	0.9	2.8	400	0.5	4.4
600	0.9	3.0	600	1.0	3.9
1000	1.5	4.2	1000	—	—

1) The surface waters from Sagami Bay and Suruga Bay are richer in copper and zinc than those from the "Kuroshio" area, confirming that the former are still affected by land drainage to any measurable extent.

2) The vertical distribution, given in Table 2, shows that the contamination is limited to the surface, the amount of the elements contained decreasing in lower layers.

3) The amount, which once decrease, again rises up from the depth of 200 m. At the present stage of study, it is difficult to decide what is the main factor determining the observed raise-up. It can be said, however, that the elements set free from dead organisms by decomposition contribute in their course of falling down to the enrichment of the deeper waters, by these elements. This is usually the case which also takes place with other nutrient salts such as phosphate.

Unfortunately in the February cruise in 1953 the sampling from the "Kuroshio" area could not be carried out by an unfavourable condition of the sea. The author is now planning as the next step of the study the examination of the samples from such an area as well as from other bays. Also the study will be extended to far deeper layers than ever examined and further to the seasonal variation of the elements. Efforts are also being made to improve the sampler by which the acrylic resin coating is expected to be made more durable.

Deepest thanks are due to Professor K. Sugawara for his guidance, and to Dr. K. Suda, Director of Hydrographic Office, Maritime Safety Agency and Professor M. Uda of the Tokyo University of Fisheries, by whose courtesy the author took advantage of participating in the surveying cruises.

Recollecting the kindest help extended to me during my stay on board, sincerest condolence is also expressed to the experts and crewmen of No. 5 Kaiyo-maru

who were missing with the ship on their duty the submarine eruption of observing at the Myojin Reef.

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The Chlorinity Determination of Sea Water by Micro-analytical Method

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Abstract

The present author proposes a new procedure of chlorinity determination of sea water. In this method, it is required to take 1.5 ml of sea water which is only one tenth in quantity of the sample required in the stardard method. Consequently, silver nitrate solution required is also reduced to one tenth in quantity.

A pipet and a buret to be used in the proposed micro-method are shown in Fig. 1. The graduation of a buret is the same as that of the Knudsen's, which enables us to directly read the chlorinity. A mixed solution of uranin and starch is used as an indicator. The mean deviation of this method is about 0.01‰. By means of the proposed method, we can also save time, within the allowable limit of the accuracy.

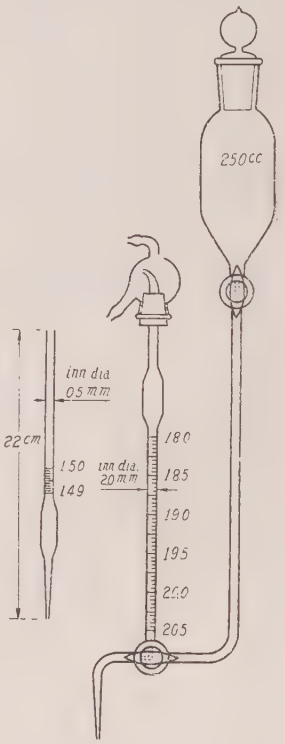

Fig. 1.

Introduction

As is well known, the system of the chlorinity determination of sea water now generally in practice was established by the International Commission about fifty years ago (1902).

The analytical technique has subsequently been much developed and now it is the time to further improve it by means of a micro-analytical method. Recently, Kalle[1] tried the chlorinity determination of coast waters using a sample of only 0.75 ml. However, the accuracy is not regarded as sufficient for more general use.

The author therefore intends to propose a procedure of chlorinity determination in which only 1.5 ml of sea water is taken for titration. This is one tenth of the quantity of sea water sample which is necessary in the standard method. As a result, the necessary amount of the silver nitrate solution with the same concentration as in the standard method is also reduced to one tenth. The buret is connected with a reservoir of the silver nitrate solution with a L-type cock.

The pipet is a kind of measuring pipet. The upper most and the lowest lines indicate 1.50 ml and 1.49 ml respectively. Between these two marks it is graduated at every 0.001 ml. The pipet and the buret to be used in the proposed micro-method are shown in Fig. 1. As shown in the figure, the graduation of the buret is the same as the Knudsen's, which enable us to read the chlorinity (‰) directly. The unit volume of the buret is equal to 0.2 ml and the volume between the minimum graduation marks is 0.01 ml.

The indicator used here by the author is a mixed solution of 5 ml of 0.1% uranin solution and 100 ml of 1% starch solution. The starch serves as a protective colloid and 0.2~0.3 ml of this indicator is added to each 1.5 ml of sea water. This indicator was first proposed by Y. Miyake[2] for the chlorinity determination and it has been in general use for the oceanographic routine works in this country with satisfactory results. The sensitivity of this indicator is so high that we can clearly recognize the end point with the difference of only about 1/2000 ml of silver nitrate solution.

Procedure

1.5 ml of sea water is taken with a pipet and emptied into a porcelein basin. The tip of the pipet is kept in contact for a while with the wall of the basin to expel the water drop remaining in the tip. The pipet is then hold vertically. Care is to be taken not to drop the residual sea water in it. Then the indicator is added and silver nitrate solution is poured from the buret into the basin with a gentle stirring until the faint pink color of the absorption indicator appears in the sample. Then, the residual water drop in the pipet is added to the sample by blowing, while the tip of the pipet is kept in contact with the wall of the basin. The pink color will disappear again and the end point is obtained by adding a droplet of silver nitrate solution. The tip of the buret as well as that of the pipet is coated with silicone resin in order to avoid the adhesion of water on their outsides. The calculation is carried out as usual by the Hydrographical Tables.

Results

The comparison of the standard and the micro-method is shown in Table 1.

Table 1. The comparison of the results by the ordinary method and the micro-method.

Sample No. 169	Standard method	Micro-method
	19.315	19.260
	19.315	19.290
	19.325	19.290
	19.310	19.310
	19.310	19.320
	19.315	19.305
Mean value	19.315±0.003	19.301±0.011

Sample No. 173	19.275	19.260
	19.285	19.270
	19.280	19.260
	19.285	19.280
	19.280	19.290
	19.285	19.260
Mean value	19.281±0.003	19.270±0.010
Sample No. 175	19.290	19.305
	19.290	19.305
	19.300	19.290
	19.285	19.310
	19.285	19.325
	19.300	19.320
Mean value	19.291±0.005	19.309±0.009

The results by the standard method show that the maximum deviation is 0.010‰, while it is 0.020‰ by the micro-method. Mean deviation is 0.003‰ by the former method, and 0.010‰ by the latter method. Such a degree of errors by the micro-method may be tolerable for routine oceanographic observations. As pointed out by Miyake[2], Mohr's method requires a longer time when we compare it with a method which uses uranin solution as the absorption indicator. According to Miyake, the ratio of the time necessary for the method by uranin solution to the standard one is about 0.4. When we use the micro-method, the time will be more shortened and it will be from 1/10 to 1/5 of the usual method. Thus, by replacing the standard method by such a micro-method, we can save much time, reagents and samples of water within the allowable limit of accuracy, and it is useful unless the higher precision is demanded.

The author expresses her hearty thanks to Dr. Y. Miyake for his kind guidance which has been extended to her throughout this study.

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On the Diatom Plankton of the Antarctic Ocean in the Summers of 1946 to 1952

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Preface. Previously the diatom plankton of the Antarctic Ocean were investigated in the cases of the *Challenger*, Deutscher Sudpolar, *Valdivia* and *Discovery* Expeditions. In the summers of 1946–1952 the staff of the Meteorological Observatories of Japan performed oceanographical observations and plankton collections by the means of nets, on the whaling ground on the Pacific Ocean side of the Antarctic continent (Table 1). The results of these planktological researches have been reported by Tamura and Sugiura (1949), Tsubata (1950), Hanzawa and others (1951), Shimomura (1952) and Marumo (1953). In the present paper, several characteristics of the Antarctic diatom plankton determined on the basis these data are explained. The observed sea areas, periods of times, observation of plankton nets and hauled distances were not always the same throughout all the cruises, but these differences will be disregarded in the present discussion.

The writer expresses his hearty thanks to Dr. Tadashi Tamura and Mr. Fumitaka Tsubata for their kind assistance.

The population of the plankton (Table 2). The population is expressed by the volume for 1 m^3 of sea water after settling for 24 hours. The average volume of a total of 138 samples, 23.5 cc, shows a high psoductivity of the Antarctic diatom planktons. Especially on the 4th cruise, the average is 66.5 cc, and the maximum 220 cc. Even on the 2nd and 5th cruises, for which the volumes are rather small, the average exceeds 7 cc. Sixty-eight out of 138 samples are in a range of 1 to 20 cc.

The average settling volumes for colder (39°N, 153°E) and warmer waters (29°N, 135°E), collected with nets of type A (see table 1) for three years are only 1.61 cc and 0.65 cc for $1m^3$ sea water, respectively. In general, moreover, animal forms such as copepods and chaetognathes are plentifully included in the samples, and hence the actual volume of diatoms decreases considerably. On the contrary, the Antarctic samples include hardly any animal forms, and it becomes clearer from the comparison that the diatom productivity is very large in the Antarctic.

It has previously been indicated by Hart (1934) and Hendy (1937) that the abundance of diatoms in the polar water can be adequately explained by the existence of rich nutrient substances. Boden (1949) also reported that the diatom

population was reduced suddenly on the north side of the Antarctic Convergence in comparison with the case of the polar water.

Species of diatoms (Table 3). The identified diatom species include only 44 throughout all the cruises; 12 in the lst cruise, 30 in the 2nd, 28 in the 4th, 34 in the 5th and 29 in the 6th. Even allowing for some species which could not be identified, it is evident that the number of species is small in the Antarctic.

Among 15 species of the genus *Chaetoceros*, 14 belong to the subgenus *Phaeoceros* and only one, *Chaetoceros neglectus*, to the subgenus *Hyalochaete*. On the whole, the majority of the diatoms are of large size in the Antarctic, while a few species such as *Nitzschia seriata* and *Fragilaria antarctica* are of small size.

It is generally said that the plankton populations are poorer in species but richer in numbers in the seas of higher latitudes. This theory is satisfactorily supported by these planktological data.

Composition of diatom populations (Table 4). Because of the small number of diatom species, the community tends to be monotonous. It is one of the remarkable characteristics of the Antarctic diatoms that a very few dominant species make up the major part of a community. As is shown in table 4, the cases where more than 50% of the total number of diatom cells belong to one and two species are recognized in 25 and 18 samples, respectively. The forty-three samples of these two cases are 96% of the total 45 samples.

It is often recognized also in warmer waters that one genus, e.g. *Chaetoceros*, forms a monotonous community, but one or two species are seldom distinctly prominent there. Conspicuous monotony in the Antarctic diatoms appears in 5 samples, in which *Corethron criophilum* makes up 89%, 90%, 91%, 93% and 100%, of the total and in 3 samples, with *Rhizoshlenia alata* occurring in percentages of 83, 94 and 96. Tamura (1949) stated that at characteristic of plankton distributions in the Antarctic was a remarkable monotony of *Corethron criophilum*.

Summary. The Antarctic diatom communities in the said summers characterized as follows:

1. The plankton productivity is very high and the average settling volume is 23.5 cc for $1m^3$ sea water.

2. The number of diatom species is very small and only 44 species were identified throughout all the cruises.

3. The diatom community is monotonous and 96% of the total samples belong to the case in which more than 50% of the total cell number is occupied by a single or two dominant species.

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Table 1. Necessary elements for consideration of planktological data.

Cruise number	Sea area	Period	※Plankton net	Hauled distance in m	Identification done by
1	62°56′S～65°33′S 164°18′E～151°10′E	Dec. 1946 ～Feb. 1947	A	various	T. Shimomura
2	60°28′S～75°37′S 148°18′E～172°28′W	Dec. 1947 ～Mar. 1948	C	0～20	T. Tamura
4	60°44′S～69°25′S 130°45′E～157°15′W	Dec. 1949 ～Mar. 1950	B	0～25	F. Tsubata
5	62°56′S～68°25′S 118°47′E～165°32′W	Dec. 1950 ～Feb. 1951	A	0～25	R. Marumo
6	65°48′S～71°38′S 162°07′W～177°00′W	Jan. 1952 ～Mar. 1952	A	0～25	R. Marumo

※	Net	Type	Diameter of mouth (cm)	Length of filtering cone (cm)	Number of mesh per inch
	A	Hensen	22.5	80	129
	B	Hensen	16	90	128
	C	Nansen	30	100	140

Table 2. Sample frequency for the settling volume and the maximum, minimum and average settling volumes for $1m^3$ sea water.

Cruise number		1	2	4	5	6	Total
Numbers of samples	1.0cc>	11	4	1	3		19
	1.1～20cc	4	36	13	4	11	68
	21～50cc	5	5	8	1	2	21
	51～100cc			17		4	21
	101cc<			9			9
	Total	20	45	48	8	17	138
Settling volume (cc/m^3)	Maximum	38.4	28.3	220	32.2	76.4	
	Minimum	0.1>	0.3	1.0	0.6	2.3	
	Average	9.4	7.1	66.5	7.4	27.1	

Table 3. List of diatom plankton.

Cruise number	1	2	4	5	6
Bacteriastrum varians				○	
Biddulphia sp.			○	○	
Asterompaalus Hookerii		⊙	⊙		○
Chaetoceros atlanticus		⊙	○	○	⊙
Ch. borealis			○	○	
Ch. Castracanei				○	○
Ch. concavicornis				○	
Ch. convolutus	○				
Ch. criophilus		⊙	⊙	⊙	⊙
Ch. danicus	○			○	
Ch. densus				○	
Ch. dichaetus		○	⊙	⊙	○
Ch. Janischianus				○	○
Ch. neapolitanus				○	
Ch. neglectus				⊙	○
Ch. peruvianus				○	○
Ch. radiculus				○	
Ch. Schimperianus				○	○
Ch. spp.	○		○		
Corethron criophilum	⊙	⊙		⊙	⊙
Cor. hystrix			⊙		
Coscinodiscus Janischianus	○				
Cos. lineatus			○		
Cos. radiatus	○		○		
Cos. spp.	○	○	○	○	○
Dactyliosolen antarcticus		⊙	⊙	⊙	⊙
Eucampia balaustium		○		○	
Euc. cornuta					○
Euc. zoodiacus				○	
Euc. sp.			○		
Fragilaria antarctica		○		⊙	⊙
F. spp.			⊙		
Nitzschia Closterium				○	○
Nit. seriata	⊙	○	⊙	⊙	⊙
Rhizosolenia alata	⊙	○		⊙	⊙
Rh. alata f.*genuina*			○		
Rh. bidens					○
Rh. Chunii					○
Rh. delicatula				○	
Rh. hebet. f. *semispina*		⊙	○	⊙	⊙
Rh. obtusa	○	⊙	⊙	⊙	⊙
Rh. simplex					○
Rh. styliformis	○	○	⊙	○	
Rh. Torpedo					○
Rh. spp.			○	○	
Synedra spathulata	⊙			○	○
Sy. pelagica			⊙		
Thlassiothrix antarctica	○	○		⊙	⊙
Th. longissima			○	○	

Double circles (⊙) denote dominant species.

Table 4. Frequency of distinctly monotonous communities.

	Cruise number	1	5	6	Total
Number of samples					
A	*Cor. cripohilum*	3		2	5
	Fr. antarctica			5	5
	Nit. seriata		3	3	6
	Rh. alata	6			6
	Sy. spathulata	2			2
	Th. antarctica	1			1
	Total	12	3	10	25
B	*Ch. danicus, Rh. styliformis*	3			3
	Ch. danicus, Th. antarctica	1			1
	Cor. criophilum, Sy. spathulata	3			3
	Nit. seriata, Rh. obtusa		1	1	2
	Ch. atlanticus, Nit. seriata			2	2
	Fr. antarctica, Nit. seriata			4	4
	Rh, obtusa, Rh. heb. f. *semispina*		1		1
	Cor. criophilum, Rh. obtusa		1		1
	Ch. concavicornis, Nit. seriata		1		1
	Total	7	4	7	18
	Grand total (A+B)	19	7	17	43
	Total of collected samples	20	8	17	45

A denotes the cases in which more than 50% of the total number of diatom cells represents single species, and B the cases of two species.

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A peculiar Chiton from Hachijo-jima with special reference to its Distribution in the Pacific

By Isao Taki

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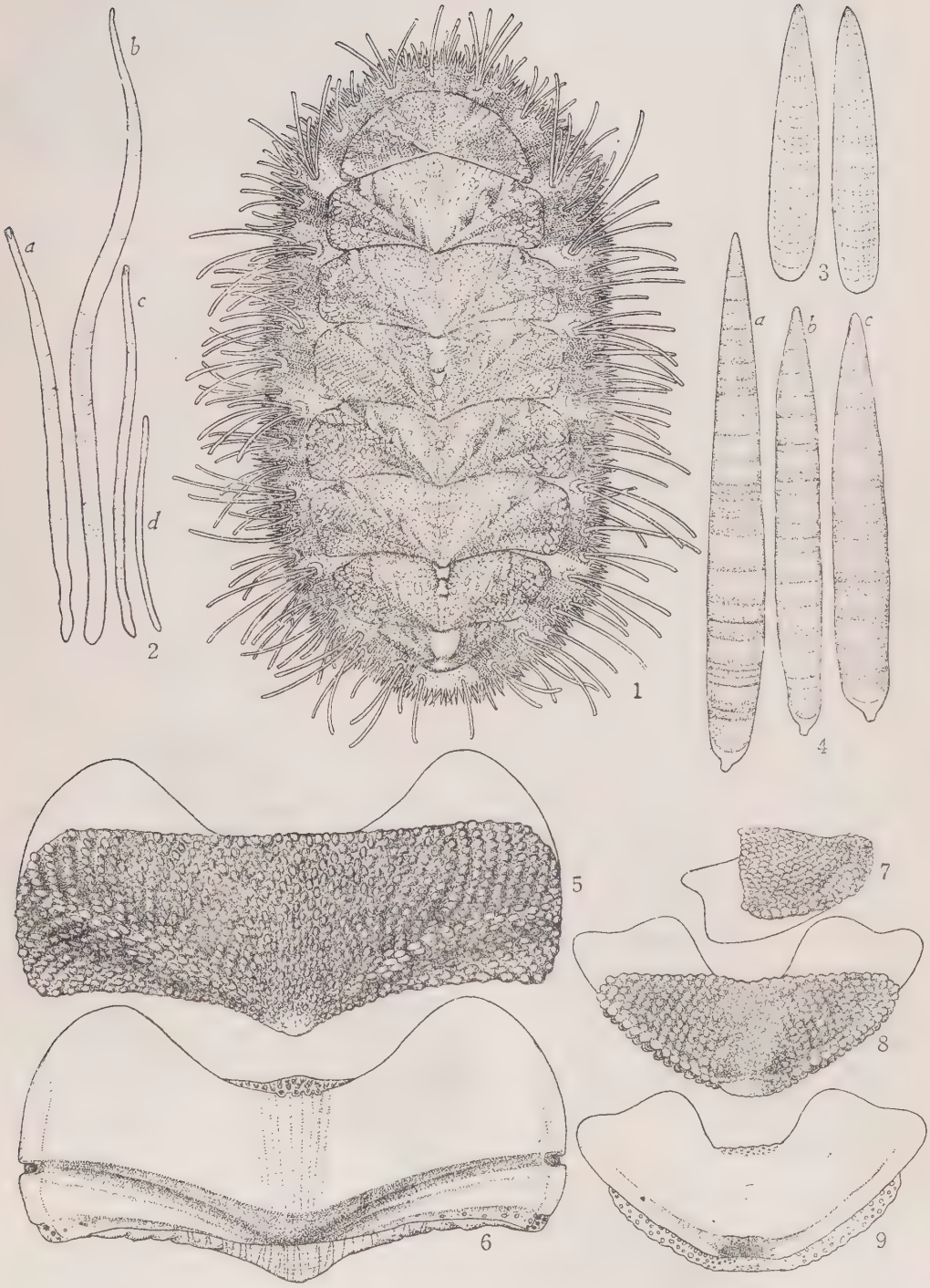
A large number of chitons was taken from Hachijo-jima and a new species was found among them. This species is so peculiar that it should be placed in the new group *Hachijomopalia*, which shows relationship partly with *Mopalia* s. str. of the Nothern Pacific and partly with *Plaxiphora* of the Southern Pacific genus. Its characteristic features and relationships with other groups are described and figured as follows.

Mopalia (*Hachijomopalia*, subgen. nov.) *integra*, sp. nov.

Body small, oval in outline; shell somewhat arched, densely granulated all over the surface: girdle moderate in width, setose with longer or shorter bristles.

Head-valve thin; apex not prominent; 8 radiating wrinkles scarcely visible, somewhat irregular in arrangement, not always corresponding with the slits; posterior edge made wavy by a series of granules on the tegmentum; entire surface densely ornamented with drop-shaped granules in reticular arrangement; eaves very short, porous; teeth somewhat long and thick, roughened by some irregular lines on both surface, but not pectinated distinctly; slits widely incised, 9 in number; interior of valve smooth, shining, pink in color: 9 slit-rays extending from apex to each slit, whitish, neither grooved nor pitted; posterior tegmental edge wide, thick, brownish red in color with many fine growth lines and crossing white lines.

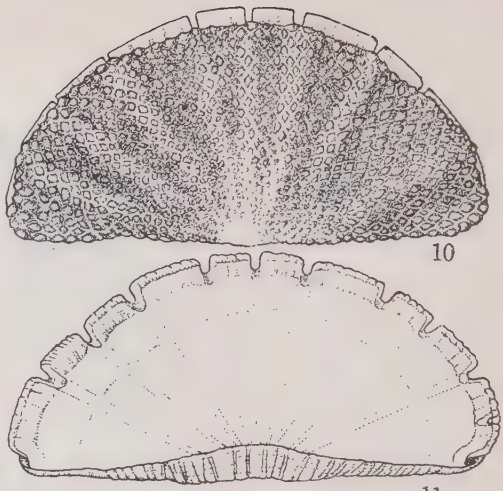
Median valves oblong in shape, nearly straight at the anterior edge, except for the second valve, slightly beaked at the posterior edge at the middle, arcuated on the dorsal surface; jugal area not defined from pleural area; central area provided with 2 series of drop-shaped granules, one arranged longitudinally and the another arcuated inwardly; lateral area distinct, bordered from central area by a diagonal rib, ornamented with small drop-shaped granules similar to the lateral area; posterior edge made wavy by the granules; interior of valve smooth, shining, with a low central callus transversely at about the middle; jugal region striated longitudinally by some whitish lines, without any transverse fine threads; slit-ray whitish, not grooved nor pitted, but the posterior margin of the articulamentum shallowly grooved, provided with a few large pits, which seem to be continuations of porous structure of eaves; teeth rather short, thin; slits distinct, 1 on each

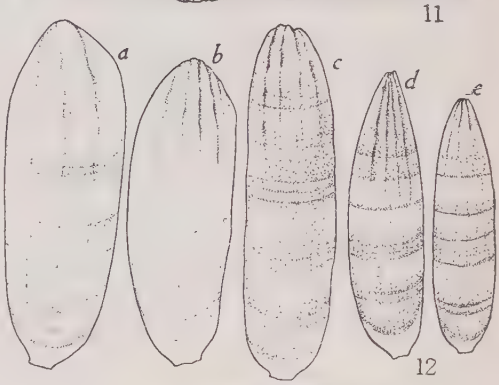


Mopalia (*Hachijomopalia*) *integra*, sp. nov.

Text-fig. 1. dorsal view of Holotype. 10×6 mm.
2. setae of perinotum; a. 1.4 mm; b. sutural seta 1.8 mm; c. 1 mm; d. 0.6 mm in length.

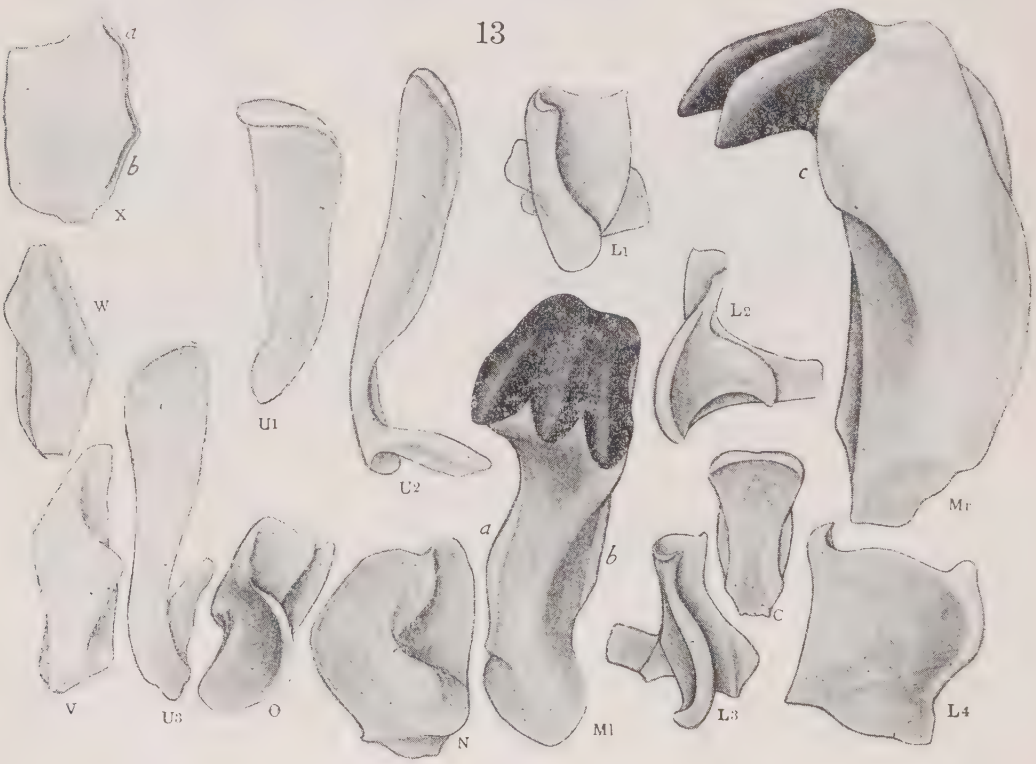
3. spicules of hyponotum, 100 μ in length each.
4. marginal spicules; a. 310 μ; b. 305 μ: c. 300 μ in length.
5. the 4th valve, dorsal view, 3.5 mm in width, divergence 145°.
6. interior of the same.
7. left side of tail-valve.
8. tail-valve, dorsal view, 2.5 mm in width.
9. interior of tail-valve.
10. head-valve, dorsal view, 3.5 mm in width.
11. interior of the same.
12. calcareous spines on the perinotum,; a,b. hyaline, 107 μ, 80 μ; c—e. brown, translucent, 107 μ, 80 μ, 70 μ in length.





Text-fig. 13 Radula of *Mopalia integra*, sp. nov.

C. central; L1. left centro-lateral, showing especially inner margin; L2. right centro-lateral, showing especially basal plate; L3. showing especially outer margin of left centro-lateral; L4. showing especially interior of right centro-lateral; M1. left major lateral, seen from inside; a. outer basal dilation, b. inner basal dilation; Mr. right major lateral, seen from outside; c. outer anterior dilation; N. 2nd lateral; O. 3rd lateral; U1. right major uncinus; U2. left major uncinus, seen from inside; U3. left one; V. 2nd marginal; W. 3rd marginal; X. 4th marginal, a. joint with postero-outer margin of the same.



side; sutural plate rounded triangular in outline, thin, broad, separated completely by a shallow, wide sinus into 2 plates; sinus densely porous at the base.

Tail-valve small, triangular in outline, nearly straight at the anterior edge, slightly arched on both sides, nearly straight at posterior end of tegmentum; mucro low, situated at about the posterior fifth of the tegmentum, directed a little forward at the tip; diagonal ribs weaker and lower than those of the median valves; central area provided with granules similar to those of median valves; posterior area small, sloped gently, densely granulated on the whole surface; interior of the valve thickened posteriorly, forming a low callus along the posterior margin; posterior end of articulamentum nearly straight, slightly sinuated at the caudal callus, but not forming a distinct caudal sinus, with several pores on the surface; sutural plate broad, nearly squarish in outline, truncated at the anterior edge, sinus deep, narrow, porous at the base; eaves rather broad, loosely porous, without any sign of slit on the posterior callus.

Girdle nearly equal in width everywhere, slightly encroaching at the suture; perinotum covered densely with minute calcareous spines all over the surface; marginal spicules long, hyaline, smooth on the surface, pointed at the tip, with a small cup at the base; sutural bristles long, somewhat curved, amber-colored, tapering towards the tip, rounded at the base, without any spicule at the distal end; bristle tuft composed of 2~4 bristles, situated at the suture; 4 such trufts around the head-valve, 2 tufts on each side of the tail-valve; smaller one nearly halfway between these primary tufts and smaller tufts or solitary series of bristle are set successively at the immediate outside between the preceding ones; hyponotum covered densely with minute spines, hyaline, with pointed tips and longitudinal fine striations.

Radula: central tooth with an arched edge at the tip, slightly sinuated on the anterior margin at the middle, shallowly sinuated on both sides; basal plate oblong, somewhat constricted posteriorly, with 2 small processes on both sides of the end; prop-plate rhomboid anteriorly, dilated posteriorly; centrolateral with a small wing at the anterior corner on the outer edge, prominent a little at the inner anterior corner, slightly arcuated at the anterior edge; major lateral tricuspid; shaft dilated a little at the outer margin of base and of anterior end and also at the inner basal margin; major uncinus long spoonshaped, inwardly curved near the base, with a large basal plate.

Measurement: length 10 mm., breadth 6 mm.

Type locality: Ōkataura, Ōkago-mura, Hachijō-jima, on the stone at low tide; 3 specimens.

Remarks: This species differs from all members of *Mopalia* s. str. in the granular sculpture on the tegmentum, the radial wrinkles on the head valve, the slit-less tail-valve and other charateristic as shown in the following table.

Table

Charaters \ Group		*Mopalia* s. str.	*Hachijomopalia*	*Plaxiphora*
tegmental sculpture		reticulum	granular	granular or ribbed
ray-ribs of head-valve		distinct, tuberculate	indistinct, granular	indistinct or smooth
head slit		8	9 (8)	8
interior jugal region		transverse threads	smooth	smooth
slit-ray		grooved, pitted	smooth, not pitted	smooth, not pitted
tail-valve		2 slits	no slit, low callus	not slit, thick callus
caudal sinus		distinct	scarcely sinuate	scarcely sinuate, *P. setiger*: entire, *P. fernandezi, fremblyi, schauinslandi*
caudal end of girdle		incised	entire	entire
perinotum		bristles with aciculae or terminal spinules	neither acicula nor spinule on bristle	with terminal spinules
central tooth	shaft	dilated on both sides	not dilated, constricted posteriorly	not dilated, constricted posteriorly
	base	2 processes at posterior end: *M. hindsi* straight: *M. retifera, ciliata, lignosa*	2 processes	straight or nearly so; *P. setiger, tricolor, fernandezi*
	anterior edge	straight	sinuated	sinuated: *P. tricolor, fernandezi.* produced: *P. setiger.*
centro-lateral tooth		small winged at outer corner	small winged	small winged

As seen in the above table, the present spcies differs from *Mopalia* s. str. and *Plaxiphora* in the features characteristic of bristles on the girdle, and from *Mopalia* s. str. in the tail-slit and the tail-callus, which are both common features of *Plaxiphora.* Most *Plaxiphora* species have the mucro at the posterior end of the tail valve, while the present new species has it a little apart from the posterior end, like *Mopalia* s. str.

The tail-valve of *Semimopalia* is sinuated at the caudal end like *Mopalia* s. str. but there is no slit on the tail, the 5th and 6th median valves. The entire tail-valve of *Semimopalia* is similar to that of the new species, whereas the latter has a slit on both sides of all the median valves. Therefore a new group should

be prepared for the new species (*Hachijomopalia*). It seems to be natural to treat the new group as a subgenus of *Mopalia*, because it will be the nearest akin to *Mopalia* s. str. of all groups of Mopaliidae in many points, as decribed above.

Type. The Holotype and 2 paratypes are preserved in the Zoological Department, National Science Museum, Tokyo. Coloration. Holotype: central area of tegmentum painted with dark brown, white and green patches on the posterior boundary and on some jugal regions on the ground color of yellowish buff; lateral area finely mottled with small white and green patches and large vermilion maculations; girdle generally brownish buff, light buff at sutures, caudal end and at base of bristle-tufts.

Paratype (a): blue and dark brown patches on the apex and the 2nd jugal region on the ground color of milky white; central area of the 2nd valve streaked with 3 brown maculations on each side; jugal boundaries of other valves mottled with blue, dark brown on the light blue ground color: girdle light buff throughout.

Paratype (b): shell colored with purplish brown all over the surface, freckled sparsely with deep blue, especially on the jugal region; girdle brown throught.

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Larviparous Oysters from the Tropical West Pacific

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Out of about 100 species of oysters inhabiting tropical or temperate regions, about 10 species are known to be larviparous. In a previous paper (1942), the author reported that oysters of four species from the Palau Islands, *Ostrea cristagalli*, *O. cumingiana*, *O. crenulifera* and *O. hyotis*, are larviparous. After that, additional observations were made on *O. crenulifera* at Misaki, Japan, and further scrutiny of the data reveals doubt as to whether *O. hyotis* is a larviparous species, although occurrence of the larviparous mode of reproduction in the other three species is unequivocal.

Since the previous paper was written in Japanese, some of the results presented in that paper will be reproduced here, with a description of further findings on *O. crenulifera* and an amendment of the previous report.

The works was carried out at the Palau Tropical Biological Station, Palau, West Carolines, in 1940 and at the Misaki Marine Biological Station, Misaki, in 1943.

Materials were obtained from the vicinity of these stations.

Results

Ostrea crista-galli Linné. Oysters of this species inhabit the lagoon waters of the Palau Islands. The animal is found in the water from the low water mark to the bottom. It is never found in tidal regions. The animals not infrequently live gregariously, fixing to coral rocks near the upper edges of coral cliffs which border the water channels between the islands. The shell-height commonly reaches about 8 cm.

Observation of gonads was made in May and August. Generally speaking, the gonads were found to be not fully developed in May. Of 16 animals examined in May, 9 were found in the male phase, 2 in the female phase and 3 individuals showed a hermaphroditic condition, while 2 were found to be in a spent condition. In August, animals with well matured gonads were commonly found. Of 20 individuals, 13 were in the male phase, 3 in the female phase, and 4 were hermaphroditic. One small individual, measuring 35×25 mm, was found to be still sexually undifferentiated.

In August, two individuals were found carrying veligers on their gills. In one of them, the veligers were in an early stage of development, white in color with D-shaped shells. The shell, measuring 110 μ in length, 85 μ in height and 50 μ in hinge-length, did not yet cover the whole soft part of the body. In the other animal, the veligers were well-grown, being old-rose in color. The shell-valve measured 153 μ in length, 137 μ in height and 70 μ in hinge-length. Three pairs of teeth had made their appearance on each side of the hinge. The hinge was tinted reddish brown. The umbo had just begun to protrude above the hinge line.

On being released into sea water, these veligers swam about actively, forming columns in a glass jar, as is commonly observed in free-living veligers of other bivalves. In this species, the veligers seem to be released from the maternal branchial cavity at this stage of development.

As in other larviparous oysters, "sperm-balls" of motile spermatozoa were always observed when male gonads were expressed in sea water. Gonadal eggs, when mature, are spherical in form, and 85 μ in diameter; although the germinal vesicle is present, it cannot be seen through a microscope in intact eggs, owing to the heavy accumulation of yolk matter in the cytoplasm.

It is noted that all individuals measuring under 50 mm in shell-height were found in the male phase, while in larger forms, all the cases of sexuality were represented.

Ostrea cumingiana Dunker. Oysters of this species generally show a habit similar to that of *O. crista-galli*. Sometimes animals of these two species were found forming a clump together. Molluscs of the present species were also found in tidal regions near the low water mark.

Examinations on the conditions of the gonads were made from May to August. During these months, animals well developing gonads were common, while in some specimens, the gonads had developed only slightly. The observation included 29 individuals in the male phase, 6 in the female phase and 8 hermaphrodites. Sperm-balls were always found in male or hermaphroditic follicles. Eggs occurring in mature gonads were oval in shape, measuring about 175×165 μ on an average. This probably is the largest among the eggs of the larviparous oysters. Eggs were heavily laden with yolk granules and opaque under a microscope, the germinal vesicle present. The vitelline membrane was very fragile, as in cases of other larviparous oysters. In the middle of June, one animal carrying embryos in an early developmental stage was found.

Ostrea crenulifera Sowerby. Oysters of this species are commonly found on reef flats, attaching to coral boulders or dead corals.

Although examination of gonadal conditions was not made at Palau, the swarming of veligers, that is, the release of veligers from the parental mantle cavity, was observed in the laboratory in the middle of September. The shell-valve

of the veliger measured 180 μ in length, 160 μ in height and about 85 μ in hinge-length. The veliger was tinted light green all over the body; the larval liver was lightly yellowish brown in color. A pair of eye-spots were very prominent. The veliger was D-shaped, the umbonal region not yet protruding.

Oysters of this species are also commonly found around the low water mark in the vicinity of the Misaki Marine Biological Station. On these oysters, observations were made during the months from May to August.

The results of observation on the ripeness of the gonads and the number of gravid oysters are summarized in Table 1. In the table, the condition of the gonads is expressed by the terms, A, B, C, D and Spent, in the order of ripeness.

Table 1. Reproductive activity of O. crenulifera (Misaki, 1943).

Date	Gonadal conditions					Total	Gravid oysters			
	A	B	C	D	Spent		Black-sick	White-sick	Total	%
May 20	10	7	2	2	0	21	0	0	0	0
June 5	13	2	0	0	0	15	0	0	0	0
June 19	2	6	4	7	10	29	3	4	7	24
29	2	5	5	1	15	28	1	0	1	3.5
July 2	6	9	13	15	11	54	1	6	7	13
3	4	8	15	18	23	78	1	4	5	6.5
5	3	7	8	13	10	41	1	11	12	29
Aug. 12	4	9	6	4	26	49	0	1	1	2
16	3	5	6	5	25	44	3	7	10	23
Total						359			43	

The figures represent the number of oysters. Ripeness of the gonads is conventionally expressed by the terms A, B, C, D and Spent in the order of their development.

Inspection of the table clearly shows that spawning was inaugurated about the middle of June and lasted through July and August. It is noted that, with only one exception among 43 cases, all of the gonads of the gravid animals were graded into one of the classes, C, D or Spent. The smallest individual among the embryo-bearing oysters was 15 mm in shell-length.

Sperm balls were always observed if the male gametes were recognized. On one occasion, spawning of sperm occurred in an oyster which was observed to have previously discharged veligers. This fact indicates that the animal functioned as a female immediately before shedding sperm. The freshly shed spermatozoa were all aggregated in speam balls, measuring about 20–50 μ in diamater, and no free spermatozoa were present.

Ripe gonadal eggs are oval or spherical, the diameter measuring 104 μ on an average (mean of 12 measurements). The germinal vesicles of these eggs were broken down when the eggs were exposed to ammoniacal sea water. Breakdown occurs at 60–70 minutes in 1×10^{-3} N NH_4OH sea water. If insemination occurs in such hyperalkaline sea water, fertilization can be accomplished artificially. Formation of first and second polar lobes was observed in eggs fertilized in this manner. According to Seno (1929), formation of polar lobes does not occur in the development of eggs of *O. denselamellosa*.

Black pigment appears in the liver when the shell of the embryo grows to 175 μ in length, 145 μ in height and 85 μ in hinge-length; at this stage, an eye-spot has appeared on the left side, but the intestine has not yet formed a loop. The aggregation of larvae at this stage is still designated as "white-sick", the larvae appearing opaque because of abundant yolk granules.

In a "black-sick" veliger measuring 185×160 μ, in which the eye-spot is still one-sided, the crystaline-style sac is formed, the intestine looped, the hinge-teeth making their appearance. From these stages on, the larvae are still retained in the mantle cavity of the parent oyster. The stomach of these veligers was observed to contain minute bits of food matter.

Swarming of the larvae was observed in the middle of August. These larvae measured 184–204 μ in shell-length, 163–177 μ in shell-height and 78–82 μ in the length of the hinge line. The mean is 192 μ, 171 μ and 81 μ respectively. However, the size at which the larvae are released from the maternal branchial cavity appears to very with the brood. One brood was found being retained in the mantle cavity which consisted of veligers measuring, on an average, 203 μ in shell-length, 180 μ in shell-height and 87 μ in hinge-length, these being considerably larger than the just mentioned, discharged veligers.

At the stage when it is released, the veliger has developed a pair of large, black eye-spots, and two pairs of interlocking teeth are present on each sides of the hinge. An individual tooth measures 4–7 μ in base-diameter and ca. 3 μ in height. The distance between neighboring teeth of the left and right sides is about 45 μ. These teeth persist throughout the following development of the veligers. In the style sac, cilia beating in waves towards the stomach are not infrequently observed.

Further development of the shelled larvae was traced from an examination of plankton samples collected in August. The free-swimming veliger can be indentified by the presence of prominent eye-spots at the base of the foot and the black color of the liver; a yellowish brown tinge which occurs in an antero-dorsal area of the liver also presents a useful feature for species identification.

Fully-grown veligers, which were observed crawling on the bottom of the glass

dish, measured 325–340 μ in shell-length and 315–325 μ in shell-height (measurements on the left valve). Spat fall was observed to have occurred on slates submerged in August. On the young spat thus obtained, measurements of the larval shell were made: left, i.e. underside, valve measured 314–331 μ (average 319 μ) in length, and 334–367 μ (av. 347 μ) in height (5 measurements each), while the right, upper valve measured 308–328 μ (av. 314 μ) in length and 314–334 μ (av. 327 μ) in height (8 measurements each).

Discussion

Judging from the facts presented above, it is certain that oysters of the three species, *O. crista-galli*, *O. cumingiana* and *O. crenulifera*, are larviparous. As far as the writer knows, excluding these three species, a larviparous mode of reproduction is known to occur in the following 9 species:

O. edulis, O. denselamellosa, O. angasi, O. circumpicta, O. futamiensis, O. equestris, O. lurida, O. lutaria, O. plicata.

(Amemiya, 1933; Gutsell, 1926; Orton, 1937; Seki, 1929, 1934).

All of these oysters are inhabitants of temperate waters. This fact leads Orton (1937) to the erroneous conclusion that larviparous oysters "occur in temperate regions", while oviparous species "occur in warm to tropical regions".

Amemiya (1933) listed a species-unknown oyster of the South Seas in the list of larviparous oysters. Since no description was given about this, it is quite uncertain to what species this oyster belongs. However, it is highly probable that further search would bring to light many other larviparous forms in the tropical waters.

Seno (1936) was of the opinion that *O. crista-galli* is oviparous. Since no evidence has been presented in this support, however, his conclusion seems to be imaginary. The old-rose color of veligers retained in the branchial chamber of this species is very unusual. No such coloration occurs in veligers of other forms. If a similar terminology to "black-sick" or "white-sick" is applied to this species, *O. crista-galli* gravid with veligers should be called "rose-sick", although, in this case, the color is primarily contributed by the shell-valves and not by the liver.

In the freshly released veligers of *O. crenulifera*, a very marked difference has been observed in the tinge of the liver between a brood from oysters of Palau and that from oysters of Misaki. No black tinge was observed in the Palau batch. Moreover, the size of the veligers at release is smaller in the tropical batch than in the Misaki batch. At present, nothing can be said as to whether these differences are individual or ecological, or genetical. This is left for further examination.

As has already been stated, the size of veligers at release varies considerably between broods of oysters of the same habitat. A similar fact is also reported in *O. lurida* by Hopkins (1937) and Davis (1949).

Further, it has been shown by the writer (1942), through a feeding experiment on *O. glomerata*, that the liver of a D-shaped veliger can readily change its color, the color depending on the nature of the food digested. Differences in the tinge of the veliger liver between broods, though less marked than in the case of *O. crenulifera*, are also reported in *O. lurida* by Hopkins (1937).

The appearance of the eye-spot in an early veliger stage seems to be unique to *O. crenulifera*. In other larviparous oysters, in which the development of the veliger is known, eye-spots appear at a rather late umbone-stage of the free-swimming period. In *O. denselamellosa*, the eye-spot (pigment spot) does not make its appearance in veligers in which the shell-length measures less than 310 μ (Seki, 1930). Similar is also the case in *O. futamiensis*, *O. lurida* and *O. edulis* (Davis, 1948; Hori, 1933; Horst, 1882; Seki, 1930).

In the previously cited paper (Wada, 1942), it was reported that *O. hyotis* Linné is larviparous, because of the discovery of a "white-sick" individual. In this specimen fertilized ova were found between the lamellae and filaments of the gills. However, since the animal had been previously been exposed to the air for several hours before examination, it is not improbable that shed ova might have been retained in the branchial cavity without being discharged to the outside sea water.

In *O. echinata*, an oviparous oyster, it is usually observed that if a spawning female is removed from the sea water, the ova shed from the genital openings are accumulated in the branchial cavity through the ostia of the gills. This will give the "white-sick" appearance of the larviparous oysters.

In *O. hyotis*, hermaphroditic animals were frequently observed. However, this cannot be an unequivocal criterion for larviparous reproduction. Moreover, sperm balls were never observed in this species, while free motile spermatozoa were present in abundance.

Judging from these facts, it is precocious to conclude that *O. hyotis* is larviparous. The problem is left to be solved in the future. Unfortunately, oysters of this species were only sparsely found in the vicinity of the Tropical Biological Station.

Summary and Conclusion

1. Oysters of three species which inhabit tropical water are larviparous. These are *Ostrea crista-galli* Linné, *O. cumingiana* Dunker and *O. crenulifera* Sowerby; the last-named is also found along the southern coast of Japan.

2. Veligers of *O. crista-galli* which are believed to be ready for release from the brachial cavity are old-rose in color.

3. The size of veligers of *O. crenulifera* discharged into the sea water is variable. These veligers are provided with a pair of very distinct eye-spots. The appearance of eye-spots at such an early veliger stage does not occur in other

larviparous oysters. A fully-grown veliger which set as a spat measures about 320 μ in shell-length and 350 μ in shell-height.

4. A marked difference has been observed in the tinge of the larval liver at the time of release between veligers of *O. crenulifera* from Palau and those from Misaki.

5. Whether *O. hyotis* is larviparous or not, cannot be decided at present.

The writer wishes to express his indebtedness to Dr. Shinkishi Hatai, the former director of the Palau Tropical Biological Station, and to the Director of the Misaki Marine Biological Station. He is also deeply indebted to Dr. Jean C. Dan in the preparation of the manuscript.

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Preliminary Report on the Brachyuran Crustacea of Hachijo Island

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This paper deals with the Brachyuran Crustacea of Hachijo Island, the material of which consists of, 1) the collection made by Mr. Osamu Umebayashi of the Tokaiku Fisheries Expeaimental Station during his stay there in 1951—1952, and 2) the collection made by myself during my exploring tour in July of 1952 under the auspices of the Japan Society for the Promotion of Scientific Research.

The species of both collections number 62 in all, referable to 49 genera and 11 families; they are mostly restricted to the littoral inhabitants; the deeper bottom was not explored. However, I am expecting that many gaps of species and genera will be filled in during my next exploring tour planned for April of 1953.

I am grateful to Dr. Shinkishi Hatai, Prof. Emeritus of Tohoku University, to Dr. Prof. Koji Hidaka of Tokyo University, under whose auspices the present research has been carried on, and to Mr. O. Umebayashi, who was kind enough to place his collection at my disposal during the present study.

List of crabs of Hachijo Island with localities.

(Species)	(Localities in Hachijo Island: A.....Yaene B.....Mitsune C.....Borawazawa)	(Northern limit of distribution of each species in four main main islands of Japan)
Fam. Dromiidae Alcock.		
Dromidiopsis dormia (Linné)	A	Kii Peninsula.
Cryptodromia tumida trispinosa Sakai	A, B	Kii Peninsula.
C. canaliculata Stimpson	A	Kii Peninsula.
Petalomera fukuii Sakai	A	Tokyo Bay
P. wilsoni (Fulton & Grant)	C	Mutu Bay.
Fam. Dynomenidae Ortmann.		
Dynomene hispida Desmarest	A, C	Kii Peninsula.
Fam. Calappidae Dana.		
Calappa calappa (Linné)	A, C	Sagami Bay.
Fam. Leucosiidae Dana.		

Merocryptus lambriformis A Milne-Edwards
.....A .....Sagami Bay.

Fam. Raninidae Dana.

Ranina ranina (Linné) .....C .....Sagami Bay.

Fam. Hymenosomidae Stimpson.

Elamena truncata (Stimpson) .....A.....Tokyo Bay.

Fam. Majidae. Alcock.

Camposcia retusa Latreille .....A, C .....Tokyo Bay.
Zewa nipponica Sakai .....A, C .....Tokyo Bay.
Menaethius monoceros Latreille.....A .....Tokyo Bay.
Huenia proteus de Haan .....A.....Tokyo Bay.
Schizophrys aspera (H. Milne-Edwards)
.....A, C .....Sagami Bay.
Micippa philyra (Herbst) .....A, B, C .....Tokyo Bay
Tiarinia cornigera Latreille ....A, C .....Bosyu.
T. spinigera Stimpson .....A, C .....Kii Peninsula.

Fam. Parthenopidae Alcock.

Ceratocarcinus spinosus Miers .....A .....Kii Peninsula.

Fam. Portunidae Dana.

**Caphyra rotundifrons* A. Milne-Edwards
.....A.....[New record in the Far East.]
Neptunus (*Neptunus*) *sanguinolentus* (Herbst)
.....A .....Tokyo Bay.
**Charybdis obtusifrons* Leene .....A .....[Northern Daito-jima.]
Thalamita prymna (Herbst).....A .....Tokyo Bay.
Th. picta Stimpson .....A, C.....Sagami Bay.

Fam. Xanthidae Alcock.

Carpilius maculatus (Linné).....A, C.....Kagosima Bay.
C. convexus (Forskal) .....A, C .....Sagami Bay.
Atergatis floridus (Linné).....A, B, C .....Tokyo Bay.
**Zozymus aeneus* (Linné) .....A, C .....[Loo Choo.]
Daira perlatus (Herbst) .....C .....Kagosima Bay
Xantho (*Leptodius*) *exaratus* (H. Milee-Edwards)
.....A, B, C .....Tokyo Bay.
X. (*L.*) *sanguineus* (H. Milne-Edwards)
.....A, B, C..... Miyazaki Prefecture.
X. (*L.*) *gracilis* (Dana).....A .....Kii Peninsula.
Xanthias lamarckii (H. Milne-Edwards)
.....C .....Kii Peninsula.
**Carpilodes bellus* (Dana) .....A, B, C .....[Bonin Isls.]
**Atergatopsis signatus* (Adams & White)

.....C .....[Northern Daito-jima.]
Actaea savignyi (H. Milne-Edwards) ...A, C .....Tokyo Bay.
A. tomentosa (H. Milne-Edwards).....A .....Kagosima Bay.
A. lata Borradaile .....A.....Tosa Bay.
**Chlorodopsis areolata* (H. Milne-Edwards)
.....A, C .....Amami Ohsima.
Chlorodiela laevissima (Dana) .....A, C .....Izu Peninsula.
Ozius rugulosus Stimpson .....A, C .....Kagosima Bay
**Eriphia laevimana* Latreille .....A, B .....[Loo Choo.]
E. l. smithii McLeay .....A, B, C.....Sagami Bay
Actumnus forficigerus (Stimpson) .....A.....Sagami Bay.
Pilumnus vespertilio (Fabricius) .....A, B .....Izu Peninsula.
Heteropanope glabra Stimpson .....A .....Tosa Bay.
Trapezia cymodoce Herbst .....A.....Kii Peninsula.

Fam. Grapsidae Dana.

Grapsus strigysus Herbst .....A, C .....Kagosima Bay.
Geograpsus grayi (H. Milne-Edwards)...A, B, C .....Tosa Bay.
**G. lividus stormi* de Man .....A.....[Northern Daito-jima.]
Pachygrapsus crassipes Randall.....A, B, C .....(Non tropical, all around Japan)
P. minutus A. Milne-Edwards .....A, B, C .....Kii Peninsula.
Acmaeopleura parvula Stimpson .....A, C .....Sagami Bay.
Planes minutus (Linné)..... A, C .....Sagami Bay.
Varuna litterata (Fabricius) .....A .....Sagami Bay.
Eriocheir japonicus de Haan .....C.....(Non-tropical, all around Japan)
Gaetice depressus (de Haan) .....C .....Hakodate, Hokkaido
Sesarma (Sesarma) intermedia (de Haan)
.....A, C .....Tokyo Bay.
Cyciograpsus intermedius Ortmann .....A, C .....Sagami Bay.
Plagusia dentipes de Haan .....A, B, C .....Iwate Prefecture
P. depressa tuberculata Lamarck .....A, B, C .....Sagami Bay.
Percnon planissimum (Herbst) .....A, B, C .....Tokyo Bay.

*The species marked with an asterisk has not yet been obtained in four main islands of Japan.

Remarks on the features of Brachyuran fauna of Hachijo Island

1. The crabs thus far collected are mostly restricted to the littoral inhabitants on rocky or stony beaches excepting a few, which were trawled up by fishermen. They belong mostly to the pure tropical species, propagated from the southern tropical regions directly by the warm current "Kuro-siwo". The general features of this fauna seem to resemble those of crabs found in the southern islands such

as Northern Daito-jima, Tori-sima or the Loo Choo Islands; the Japanese endemic species are considerably rare.

2. No representative of the northern cold regions of the Pacific has yet been obtained, although a branch of the cold current "Oyasiwo" is said to approach the northwest beach of this island.

3. The discovery of the following seven species is noteworthy, as they have not yet been obtained in any of the four main islands of Japan.

Caphyra rotundifrons A. Milne-Edwards.
Charybdis obtusifrons Leene.
Zozymus aeneus (Linné).
Carpilodes bellus (Dana).
Chlarodopsis areolata (H. Milne-Edwards).
Eriphia laevimana Latreille.
Geograpsus lividus stormi de Man.

4. Characteristics of the crabs inhabiting the high and low tidal zones are enumerated below:

Spider crabs:—*Zewa nipponica, Micippa philyra* and *Tiarinia spinigera* are the common spider crabs of this island, while the Japanese common species, *Pugettia quadridens* and its kin, are not to be seen.

Xanthoid crabs:—The tropical *Xantho* (*Leptodius*) *sanguineus* is more abundant than *X.* (*L.*) *exaratus*, which is very common in the Japanese mainland. *Carpilodes bellus*, which has been found in the vicinity of Japan only in the Bonin Isls., is also very common under stones or in crevices or the rocks.

Sand crabs: No representative of the family Ocypodidae can be observed, as this island has no typical sandy or muddy beaches.

Grapsoid crabs:—As in southern tropical regions, the high tidal zone of rocky beaches is characterized by the thick population of *Grapsus strigosus* and *Plagusia depressa tuberculata*. *Pachygrapsus crassipes* is also very abundant, but this species is non-tropical, being one of the common rock crabs inhabiting the socky beaches of the Japanese mainland.

The low tidal zone is thickly populated by *Percnon planissimum*, which is not so abundant in the Japanese mainland.

Hemigrapsus sanguineus, H. penicillatus and *Gaetice depressus* are very common crabs on both tidal zones around the Japanese mainland, but such species are not to be seen, except for a few specimens of the last named species on the coast of Borawazawa. The hard beach of this island seems not to allow their existence.

5. Estuarine crabs:—While Japanese fauna of estuarine crabs is very rich, represented by *Sesarma haematocheir, S. dehaani, S. picta, S. intermedia, Helice tridens, Chasmagnathus convexus* etc., it is singularly poor in this island, the only

representative being *S. intermedia*, which is abundant in Borawazawa and even in Nakanogo village, which is situated about 100 metre above sea level. All around the island, however, the tropical *Geograpsus gray* is very abundant and may be found in burrows in the groves near the beach.

6. Fresh water crabs:—While the common Japanese crab, *Eriocheir japanicus*, is abundant in the streams in the vicinity Borawazawa, contrary to expectation no representative of *Potamon* has been obtained although the clean streams of of the said region seem to provide a good ecological condition for the species of *Potamon*.

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Distribution of the Recent Foraminifera from Adjacent Seas of Japan (I)

(Izumi-nada in the Eastern Part of the Inland Sea of Japan)

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Recent progress in the Neogene foraminiferal biostratigraphy in Japan had led us to feel the necessity of establishing detailed ecological zones of the recent Foraminifera around Japan. Although several contributions to the foraminiferal ecology in the surrounding seas of Japan and its adjacent areas have been made in the past (K. Asano, Y. Hada, S. Hanzawa, J. Ikari, Y. Ishiwada, M. Maruhasi, M. Morishima, M. Chiji, N. Nagahama, T. Oinomikado, Leo W. Stach, and T. Uchio), the types of foraminiferal assemblages and their relation to the various ecological conditions within their distribution in the adjacent seas of Japan are still too little known for the paleoecological interpretation of the Neogene sediments. Fortunately. the writer had the opportunity to examine the very rich foraminiferal material contained in the marine sediments collected by the surveying ship Kishiwada of the Hydrographical Department of the former Japanese Navy from the adjacent seas of Japan and which are preserved in the Institute of Geology and Paleontology, Tohoku University.

The samples of marine sediments were accompanied by data on location of collection but not by data such as the bottom temperature and salinity. These data were furnised by the Fisheries Experimental Station and are quoted in Table 2. The data were taken during 1933 the same year as the cruise of the S. S. Kishiwada.

The purpose of this short article is to make a contribution to the ecology of the recent Foraminifera found in the adjacent seas of Japan. This constitutes the first part of a series which will be published by the present author.

In this note, the author lists the foraminiferal species identified from the various stations within Izumi-nada in the eastern part of the Inland Sea of Japan. Some oceanographic data is presethed but no interpretation is given in the present paper.

Ten grams of material from each sample of the marine sediments was used in the present work. Mmaterials were crumbled with the finger and soaked in water for disaggregation. The dried and disaggregated materials were sieved. Fractions finer than 0.1 mm were discarded and coarser fractions were treated with carbon tetrachloride. After picking all the specimens from each sample the

species were identified and counted. The number of specimens of each species and the specific names are given in the annexed list. The geographical positions, depth of dredge operation and types of sediments are given in Table.

Table 1.

Station No.	N. Latitude	W. Longitude	Depth in Meters	Type of Sediment
9080001	34°36′34″	135°05′27″	24	medium-grained sand with shell fragments
9080005	34°31′15″	135°04′30″	63	medium-grained sand with shell fragments
9080006	34°29′07″	135°59′41″	64	very fine-grained sand
9080008	34°26′55″	134°04′23″	40	silt and clay
9080011	34°23′15″	135°02′19″	40	very fine-grained sand
9080012	34°23′29″	134°55′19″	33	silt and clay
9080016	34°20′09″	135°01′55″	42	pebbly sand with shell fragments
9080017	34°20′22″	135°05′14″	33	fine sand
9080018	34°20′05″	135°08′39″	20	very fine sand with shell fragments
9080020	34°21′32″	135°11′49″	13	silt and clay
9080023	34°27′48″	135°08′39″	35	silt and clay

The author wishes to express his deep appreciation to Professors Shoshiro Hanzawa, Kiyoshi Asano and Kotora Hatai of the Institute of Geology and Paleontology of Tohoku University for kindly reviewing the manuscript and for their helpful advices.

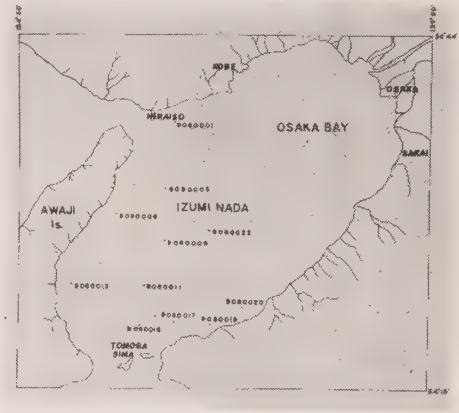

Fig 1. Map of Izumi-nada and vicinity showing locations of stations.

Table

Station		Hiraiso	Sakai				
		2M	7″	12″	17″	5″	10″
Date		III 6	″	″	″	″	″
Time		8.00	8.35	9.16	9.55	10.35	11.18
Temperature	0 m	6.9	6.7	6.9	7.3	6.9	6.9
	10	7.3	7.2	7.2	7.5	7.2	7.2
	20	7.3	—	—	—	—	7.6
	30	—	—	—	—	—	—
	40	—	—	—	—	—	—
	50	—	—	—	—	—	—
	60	—	—	—	—	—	—
	bms.	7.7	7.6	7.6	7.5	7.4	7.6
Salinity	0	31.99	31.39	31.18	30.86	31.74	31.74
	10	32.12	32.65	31.72	32.72	32.45	31.91
	20	32.12	—	—	—	—	32.00
	30	—	—	—	—	—	—
	40	—	—	—	—	—	—
	50	—	—	—	—	—	—
	60	—	—	—	—	—	—
	bms.	32.12	32.39	32.18	32.72	32.72	32.00
Depth		20	18	18	10	18	20
Date		VII 13	″	″	″	″	″
Time		8.10	9.00	9.50	10.30	11.15	12.00
Temperature	0 m	23.8	25.4	26.8	28.8	27.3	27.7
	10	23.4	23.6	26.8	—	25.4	23.8
	20	—	—	—	—	—	—
	30	—	—	—	—	—	—
	40	—	—	—	—	—	—
	50	—	—	—	—	—	—
	60	—	—	—	—	—	—
	70	—	—	—	—	—	—
	bms.	23.4	23.0	21.0	23.5	21.0	22.4
Salinity	0	34.29	34.11	29.90	25.90	30.84	30.86
	10	33.91	34.23	29.99	—	33.95	32.63
	20	—	—	—	—	—	—
	30	—	—	—	—	—	—
	40	—	—	—	—	—	—
	50	—	—	—	—	—	—
	60	—	—	—	—	—	—
	70	—	—	—	—	—	—
	bms.	34.20	33.84	34.06	32.05	32.19	32.70
Depth		18	18	18	18	18	17

Occeanographic Data for Izumi-nada during March and July, 1933. (From Imperial Report No. 52, 1933, No. 53, 1934.

2.

Tomoga Sima							Hiraiso
15″	20″	25″	1″	6″	11″	16″	21″
″	″	″	″	″	″	″	″
11.58	12.30	13.12	13.40	14.20	15.06	15.50	—
7.4	7.6	8.5	8.8	8.2	7.9	7.6	6.9
8.3	8.7	8.4	9.2	8.1	7.9	7.6	6.9
8.4	8.5	8.5	9.4	8.0	7.7	7.6	7.2
—	—	8.5	—	7.9	7.7	7.6	7.2
—	—	8.6	—	8.3	7.6	7.6	—
—	—	8.6	—	8.1	7.6	7.6	—
—	—	8.6	—	—	—	7.6	—
8.4	8.6	8.6	9.6	9.3	7.6	7.6	7.6
32.90	32.36	32.22	32.51	32.01	32.19	32.39	32.04
32.97	33.51	32.10	32.58	32.15	32.19	32.45	32.09
33.24	33.15	32.39	32.58	32.27	32.19	32.46	32.25
—	—	32.39	—	32.39	32.20	32.51	32.25
—	—	32.39	—	32.63	32.34	32.52	—
—	—	32.25	—	32.29	32.39	32.52	—
—	—	32.39	—	—	—	32.35	—
32.24	32.30	32.39	32.65	32.87	32.39	32.57	32.36
20	27	60	27	57	50	60	—
″	″	″	″	″	″	″	″
12.56	13.30	14.37	15.13	16.00	16.35	17.35	7.50
26.8	25.5	24.6	24.0	23.9	24.8	24.2	23.8
24.4	23.9	23.7	23.4	23.4	23.4	23.2	23.7
22.9	23.6	23.7	23.1	23.2	23.3	23.2	23.5
—	—	23.2	23.0	23.4	23.2	23.5	23.4
—	—	23.2	—	23.0	23.2	23.5	—
—	—	23.0	—	—	22.9	23.8	—
—	—	23.0	—	—	—	—	—
—	—	23.0	—	—	—	—	—
22.9	24.2	23.0	23.0	23.9	22.9	23.4	23.4
34.13	32.61	33.91	34.56	34.23	33.91	33.68	34.01
34.04	32.99	34.51	34.22	34.23	33.91	33.94	33.94
32.45	32.63	34.11	34.40	34.07	33.98	33.64	34.04
—	—	34.61	34.48	34.27	34.04	33.64	33.94
—	—	34.51	—	34.30	34.16	33.68	—
—	—	34.76	—	—	34.34	32.41	—
—	—	34.36	—	—	—	—	—
—	—	34.36	—	—	—	—	—
32.45	33.15	34.36	34.48	34.43	34.34	32.56	33.98
20	20	70	30	47	55	55	38

Fisheries Experimental Station, Semi-annual Report, Oceanographical Investigation)

Species \ Station Number	9080001	9080005	9080006	9080008	9080011	9080012	9080016	9080017	9080018	9080020	9080023
Reophax curtus Cushman			6			1					1
Ammobaculites foliaceus (Brady)			10		1	1			1	13	3
Textularia abbreviata d'Orbigny						2					
T. articulata d'Orbigny	16	64					37	1	3		
T. conica d' Orbigny	13	101			1		23	4	3		
T. foliacea Haron-Allen and Earland	2				7		1		6		1
T. foliacea oceanica Cushman		1						10			
T. secasensis Lalicker and McCulloch	17	29						2			
T. sp.				1		1					
Gaudryina pseudodiffformis Berthelin			8	3							
G. cf. *robusta* Cushman					1						
Eggerella advena (Cushman)		3	17	39	5	5	2	2		36	59
Quinqusloculina akneriana d'Orbigny	6	5			3		3	10	7		
Q. bicornis (Walker and Jacob)	1	2									
Q. contorta d'Orbigny		1									
Q. lamarckiana d'Orbigny					4			4	3		
Q. polygona d'Orbigny					2						
Q. sawanensis Asano								1	1		
Q. seminula (Linnaeus)			1				1				1
Miliolinella circularis (Bornemann)								1			
Massilina alveoliniformis Millet			10	2	10	1					
Spiroloculina acescata Cushman							2	1			
S. communis Cushman and Todd		1						1	2		
S. corrugata Cushman and Todd									1		
S. cushmani Hada		1			2		1		1		
S. manifesta Cushman and Todd					2						
Sigmoilina arenaria (Brady)								3	1		
S. schlumbergeri Silvestri					12						
S. tenuis (Czjzek)					2						
Triloculina rotunda d'Orbigny	4	1			1		21	7	8		2
T. tricarinata d'Orbigny	1								1		
Cribrolinoides curtus (Cushman)							1				
Trochammina discorbis Earland				1							
T. inflata (Montagu)			2								
T. pacifica simplex Cushman and McCulloch			9			4					3
T. squamata Parker and Jones								1			
T. sp.				1					1		
Robulus sp.								1			
Dentalina decepta (Bagg)							1				
Lagenonodosaria scalaris sagamiensis Asano					1						
Lagena clavata Williamson					1						
L. globosa (Montagu)					1						
L. laevis (Montagu)					1						
L. semistriata Williamson											1
L. sulcata laevicostata Cushman and Gray							1				
L. sulcata spicata Cushman and McCulloch		1	2	2						1	
Guttulina kishinouyi Cushman and Ozawa							1				
G. regina (Brady, Parker and Jones)									3		
G. yabei ovale Cushman and Ozawa								1	5		
Pyrulina sp.				1							

Pseudopolymorphina indica (Cushman)	1	2									
Sigmoidella kagaensis Cushman and Ozawa								1			
Nonion japonicum Asano				1		3					
N. manpukujiense Otsuka		2	7		25		3		1	2	
N. pacificum (Cushman)				1							1
N. scaphum (Fichtel and Moll)			7	8	1						1
N. sp.				4							
Pseudononion japonicum Asano				1			1		2		
Astrononion stellatum Cushman and Edwards								1			1
Elphidum advenum (Cushman)	1	9	5		11	1	12	36	22		2
E. cf. *articulatum* (d'Orbigny)						4				6	
E. craticulatum (Fichtel and Moll)	1										
E. excubitor Nicol	29	13		3	1			5	10		
E. incertum clavatum Cushman				1						20	
E. jenseni Cushman										12	2
E. sp.			2	4			1		1		
Bulinimina elongata subulata and Cushman Parker			1								
B. kochiensis Takayanagi			3	2							
B. marginata d'Orbigny			3	6	2	1	1		1		1
Entosolenia maginata (Montagu)				2		1					
E. orbignyana (Seglenza)				1							
E. sp.				1							
Virgulina complanata Egger			1	1							
V. pauciloculata Brady			5								
V. schreibersiana Czjzek				4		1	3	3	2		1
Bolivina acerosa pacifica Cushman and McCulloch				1	2		1				
B. advena Cushman				3							
B. compacta Sidebottom					1				1		
B. pseudodifformis Asano				1							
B. pygmaea Brady			1								
B. robusta Brady			42	22	91	8	1	2			1
B. seminuda Cushman		1	3	1	1			1			1
B. striatula Cushman			7	11	2	3	1				1
B. subangularis ogasaensis Asano					2						
Loxostomum amygdalaeforme iokiense Asano									1		
L. karreiranum (Brady)							3	1	1		
L. sp.					2						
Reussella aculeata Cushman					1					9	2
R. pacifica Cushman and McCulloch				1	2			1			
Uvigerina cf. *hootsi* Rankin			8	3		6		1			1
U. cf. *pseudoampullacea* Asano									1		
U. sp.									1		
Hopkinsina pacifica Cushman				20					1		1
Siphogenerina columellaris (Brady)		1									
S. raphana (Parker and Jones)					3		1		1		
Discopulvinulina bertheloti (d'Orbigny)					5						
D. australis (Parr)	1										
D. hofkeri Asano			1	1							1
D. cf. *isabelleana* (d'Orbigny)			1	10	23			9			
D. cf. *nitida* (Williamson)	3	3					7		8		31
Gyroidina soldanii d'Orbigny					1						

Eponides frigidus calidus Cushman		1	1							20	
E. haidingerii (d'Orbigny)	1	7			9		27	26	10		1
E. orientalis Asano								1			
Rotalia cf. *beccarii* (Linnaeus)					4	5		1		12	6
R. japonica Hada			6		2						
R. ketienziensis angulata Kuwano							2				
R. cf. *nipponica* Asano				1							
R. cf. *papillosa* Brady		8	3	1	11	4	16	23	5	2	2
R. takanabensis (Ishizaki)			6		3						
Poroeponides cribroconcameratus Asano and Uchio	2	2									
P. cribrorepandus Asano and Uchio	19	22	8					6	4		
P. lateralis (Terguem)	3	4									
Cancris auriculus (Fichtel and Moll)		1			5		1				
Cymobalopora bradyi Cushman					1			1			
Cymbaloporetta squammosa (d'Orbigny)								1			
Cassidulina asanoi Brady			2								
C. subglobosa Brady			1					1	1		
Epistominella naraensis (Kuwano)				3	1				2		
E. pulchella Husezima and Maruhashi					1						
E. tamana (Kuwano)						2					
Planulina convexa Takayanagi									1		
Hanzawaia nipponica Asano	1	1			2		9	4	2		
Cibicides lobatulus (Walker and Jacob)	3	12	2	3	8		6	9	5		2
C. cf. *refulgens* (Montfort)						2	2	3	2		
Planorbulina mediterranensis d'Orbigny		1									
Acervulina inharens Schlutze		1									
Globigerina bulloides d'Orbigny			1		1						
G. dubia Egger					1		1				
Total	125	300	191	175	283	56	194	187	132	183	130

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Records of Oceanographic Works
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New Series, December 1953

Ecological Analysis of Pelagic Shoals I

(Analysis of Salmon Gill-net Association in Aleutian, (4)
Estimation of the Longitude of the Minimum Land-influence
and the Biological Significance of the Estimated Longitude)

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Shimonoseki College of Fisheries

The vertical and horizontal segregations of salmon habitats, distribution of fishes on the net, number of shoals caught by the net and populations of shoals were analysed on the basis of original data observed at about 100 miles east of Cape Lopatka, and the fact that *Oncorhynchus keta* and *O. gorbuscha* occupied a similar habitat, while *O. nerka* was distributed independently of both *O. gorbuscha* and *O. keta* and thus no horizontal segregation of habitat was observed among these three species of salmon was reported in a previous paper (Maeda, 1953). However, it has been said that salmons, intermingling in the ocean, gradually separate and form shoals consisting of single species as they approach the land. From this fact, it is assumable that the catch-composition of each boat is similar when a group of catcher-boats work in the same area in the ocean, while the composition is not always similar when a group of catcher-boat work near the land. Thus, there are to be expected some catcher-boats, the catch-compositions of which cannot be regarded as similar to those of other boats. The ratio of such catcher-boats to the others may be used as an indicator of the degree of the land-influence upon the salmon shoals.

In this report, first the results of analysis of the land-influence upon salmon shoals on the basis of this assumption will be reported; then the biological significance of the longitude of the minimum land-influence will be discussed, reviewing the total catch of each day and consulting the results of biological observations pursued by Fukuhara (1953) in the same area.

Before entering upon these subjects, I must express my sincere thanks to Prof. Dr. D. Miyaji (Kyoto University) for his kind guidance and criticism of my work. I must also record here my hearty thanks to Dr. M. Morishita (Kyushu University), Dr. T. Tokioka (Kyoto University), Prof. Dr. I. Matsui (Shimonoseki College of Fisheries), Captain Y. Sasaki of the Syunkotsu Maru andChief inspector M. Tochinai, who afforded me advice, instruction and many facilities for carrying out this work.

I. Estimation of catcher-boats with catch-compositions being regarded as dissimilar to those of other boats, formulae of land-influence and the longitude

influenced least by land.

As catcher-boats are working within a rarge of 20 miles from the mother-ship, they may be considered as being nearly at the same position in the vast ocean. In order to estimate the number of catcher-boats with catch-compositions impossible to regard as similar to those of other boats at 0.05 level of significance, the x^2-method is applied, under the supposition that the catch-compotision of each catcher-boat is the same as that of the whole group boats, on the data obtained from the material which comprise the daily catches of eace catcher-boat belonging to the Ten-yo Maru fleet and was offered me by courtesy of the chief inspector of the Japanese Fisheries Agency. Table 1 is given below to show an example of the process of estimation. The results of the estimation, the ratio of catcher-

Table 1 Number of each species of salmon caught by each catcher-boat and x^2-values under the supposition that the catch-composition of each catcher-boat is the same as that of the total catch of the fleet. (June 6, 1952)

Number of Catcher	Catch composition				χ			
	O. nerka	*O. keta*	*O. gorbuscha*	Total	*O. nerka*	*O. keta*	*O. gorbuscha*	$\Sigma\chi_0^2$
1	389	225	6	650	2.4837	6,9280	3,2803	12,6920
2	409	49	0	458	42.3343	70.1546	8.7100	121.1989
3	294	42	0	336	26.6513	43.5782	6.3900	76.6195
4	388	87	5	480	18.6563	33.1092	1.8682	53.6337
5	545	247	12	804	1.0896	1.5755	0.7118	3.3769
6	150	42	0	192	5.2410	7.5000	3.6500	16.3910
7	306	31	4	341	32.6556	59.9392	0.9553	93.5501
8	276	418	8	702	70.4513	145.5843	2.1504	218.1860
9	270	48	3	321	18.4260	32.3810	1.5830	52.3900
10	407	120	6	533	10.9472	18.5508	1.6903	31.1883
11	414	258	3	675	1.2675	4.9637	7.5409	13.7721
12	221	361	18	600	72.5146	130.3973	3.7913	206.7032
13	517	236	24	777	0.3528	1.9667	5.7516	8.0711
14	226	117	3	346	0.0130	0.0304	1.9478	1.9912
15	607	547	42	1196	36.5224	55.8080	16.2644	108.5948
16	334	181	4	519	0.0176	0.3989	3.4911	3.9076
17	383	122	16	521	6.0681	15.2160	3.7425	25.0266
18	311	374	34	719	51.6001	75.8936	30.1829	157.6766
19	345	92	12	449	9.9963	22.0595	1.4018	33.4576
20	343	90	13	446	10.0451	22.9885	2.3958	35.4294
21	258	78	4	340	6.4182	10.9088	0.9430	18.2700
Total	7393	3795	217	11405				1292.1266

$F_0 = 32.3032$ $F_{\infty}^{40}(0.005) = 1.6691$

$d_1 f_1 = 40$

$0.05 = P_r\{x_2 > 55.7600\}$

$0.01 = P_r\{x^2 > 63.6920\}$

$0.005 = P_r\{x^2 > 66.7640\}$

boats with dissimilar catch-compositions, angle transformation values of the ratio and the daily position of the mother-ship at noon are shown in table 2.

Table 2 Total number of catcher-boats, number of catcher-boats with the catch-composition which cannot be regarded as similar, angle transformation value of the ratio of such catcher-boats to tatal catcher-boats and the daily position of the mother-ship.

No. of fishing ground	Date	Total number of catchers	Number of catcher-boats with the catch-composition which cannot be regarded as similar	Angle transformation value of the ratio	Position of the mother-ship at noon
1	May 18	16	2	20.70	$178^{\circ}{}^{55}/_{100}$
	25	29	9	33.85	$177^{\circ}{}^{32}/_{100}$
	June 1	28	5	25.00	$177^{\circ}{}^{33}/_{100}$
	6	21	6	32.31	$177^{\circ}\ {}^{3}/_{100}$
	12	21	2	17.90	$177^{\circ}{}^{82}/_{100}$
2	19	24	3	20.70	$172^{\circ}{}^{57}/_{100}$
	21	26	1	11.32	$173^{\circ}{}^{50}/_{100}$
	23	27	1	11.09	$173^{\circ}{}^{12}/_{100}$
	24	22	5	28.46	$173^{\circ}{}^{75}/_{100}$
	26	26	0	0.00	$172^{\circ}{}^{78}/_{100}$
3	29	27	4	22.64	$170^{\circ}\ {}^{2}/_{100}$
	30	26	1	11.32	$170^{\circ}{}^{23}/_{100}$
	July 1	24	2	16.77	170°
4	6	26	12	42.79	$165^{\circ}{}^{98}/_{100}$
	7	26	2	16.10	$165^{\circ}{}^{97}/_{100}$
	9	27	7	30.61	$166^{\circ}\ {}^{3}/_{100}$
5	13	27	2	15.80	$163^{\circ}{}^{12}/_{100}$
	14	25	7	31.95	$163^{\circ}\ {}^{2}/_{100}$
	15	27	4	22.64	$163^{\circ}{}^{22}/_{100}$
6	18	26	6	28.72	$161^{\circ}{}^{50}/_{100}$
	22	25	3	20.27	$161^{\circ}{}^{50}/_{100}$
	25	24	8	35.26	$161^{\circ}{}^{27}/_{100}$

The daily position of the mother-ship at noon is shown by the longitude only.

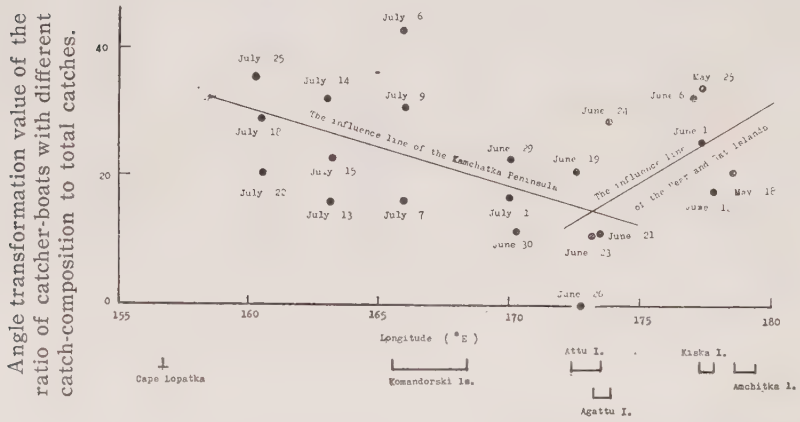

Fig. 1 Diagram showing the relation between the degree of the land influence and the longitude.

From the distribution of points in Fig. 1, it becomes obvious that the minimum influence of land is found near 173° E. Then, the data are classified into two groups, one comprising the data from the area west of 175° E and the other involving those from the area east of 173½° E, so as to overlap the area near the longitude influenced least by land. Regression lines of these groups are estimated as follows:

The former group (influence formula of the Near and Rat Islands)

$$A = 2.43L - 406.03 \qquad [F_0 = 3.57,\ F'_8\ (0.1) = 3.46]$$

The latter group (influence formula of the Kamchatka Peninsula)

$$A = 217.54 - 1.17L \qquad [F_0 = 5.56,\ F'_{15}\ (0.05) = 4.54]$$

Here, A is the angle transformation values of the ratio of catcher-boats with catch-compositions which cannot be regarded as similar at 0.05 level of significance, and L is the longitude of each sampling station. The longitude of the minimum land-influence can be calculated as follows, as the cross point of the two formulae given above.

$$217.54 - 1.17L = A = 2.43L - 406.03$$

$$\therefore \qquad L = \frac{623.57}{3.60} = 173.2139° = 173°12'50''$$

II. Biological significance of the longitude of the minimum land-influence.

If this longitude is of some biological importance, many characters of fishes ought to change suddenly on passing this longitude. Under the supposition that the total catch of the fleet changes in accordance with its position in a certain relation in the area influenced by the same land, and shows a different manner of change in the area influenced by the different land, the changing inclination of points represehting the total catch and the daily position of the fleet must differ on the two sides of the longitude of the minimum land-influence. In the present case, the change of position goes along the longitude only, because the course of mother-ship is along about the 51½° N.

From the actual data obtained in the area between the longitude of the minimum land-influence and 162° E, the formula showing the relation between the logarithmic values of the daily total catches of each species of salmons and the daily position of the fleet in the area influenced by the Kamchatka Peninsula is established. The formula for *O. nerka*, calculated thus, cannot be used, actually, because its level of significance is too low to be valid. Therefore, there has been substituted for it the formula estimated from the data obtained in the range between the longitude of the minimum land-influence and 165° E. (Represented in Table 3 as *O. nerka* (2).)

If the longitude of the minimum land-influence is of no biological importance, the daily total catches of each species of salmon from the area east of the longitude

of the minimum land-influence must be in the rejective zones of the relation formulae, given above. In order to examine whether the observed values are distributed in the rejective zone or not, the F°—value was computed in each case under the null hypothesis that the total catch in in each case is the same as the value calculated from the relation formula (table 3). The total catch of *O. nerka* in May 25, June 1, June 6 and June 12 and that of *O. keta* in May 18 and June 12 cannot be regarded as similar to the values calculated respectively from their own formulae at the 0.05 level of significance. The total catch of *O. gorbuscha*

Table 3. Formulae showing the relation between the daily total catch of each salmon species and the daily position of the mother-ship represented by longitude.

Species	Formulae	F_0	F	F_0'				
				May 18	May 15	June 1	June 6	June 12
O. keta	$\log k = 0.0295L - 1.3071$	7.1688	$F'_{12}(0.05) = 4.7472$	10.0164*	0.0555	0.0555	3.0711	9.4082*
O. gorbuscha	$\log g = 2.25254 - 0.1134L$	77.8406		—	—	—	0.2580	0.0596
O. nerka (1)	$\log n = 8.0565 - 0.0257L$	4.37						
„ (2)	$\log n = 13.9213 - 0.0601L$	29.9775	$F'_9(0.05) = 5.1174$	3.9642	26.3984*	37.7124*	19.0138*	16.0291*

Notes:
L: Noon longitude of mother-ship.
k: Logarithmic value of daily total catch of *O. keta*.
g: Logarithmic value of daily total catch of *O. gorbuscha*.
n: Logarithmic value of daily total catch of *O. nerka*.
F_0: Calculated F values of each formula.
F_0': F value in each case under the null hypothesis that the total catch in each case takes the same value as that calculated from the relation formula. Among them the significant values (at 0.05 level of sig.) are marked by an asterisk.

in May 18, May 25 and June 1 are zero, i.e., the logarithmic values are $-\infty$. F_0 becomes ∞, and consequently the total catches in these cannot be regarded as similar to the calculated values from the formula, although the importance of this conclusion is somewhat questionable.

From these results, it may safely be concluded that the relation between the daily total catch of each species of salmon and the daily position of the fleet represented by the longitude is shown in a different manner at the two sides of the longitude of the minimum land-influence. The longitude of the minium land-influence seems thus to be the critical point in this biological relation.

As a trial of this idea, I used the results of the detailed biological observations by FUKUHARA which are summarized in table 4. The reader may perceive that most of characters, except those with an asterisk, change sudeenly in June 14 when the mother-ship crossed the longitude of the minimum land-influence.

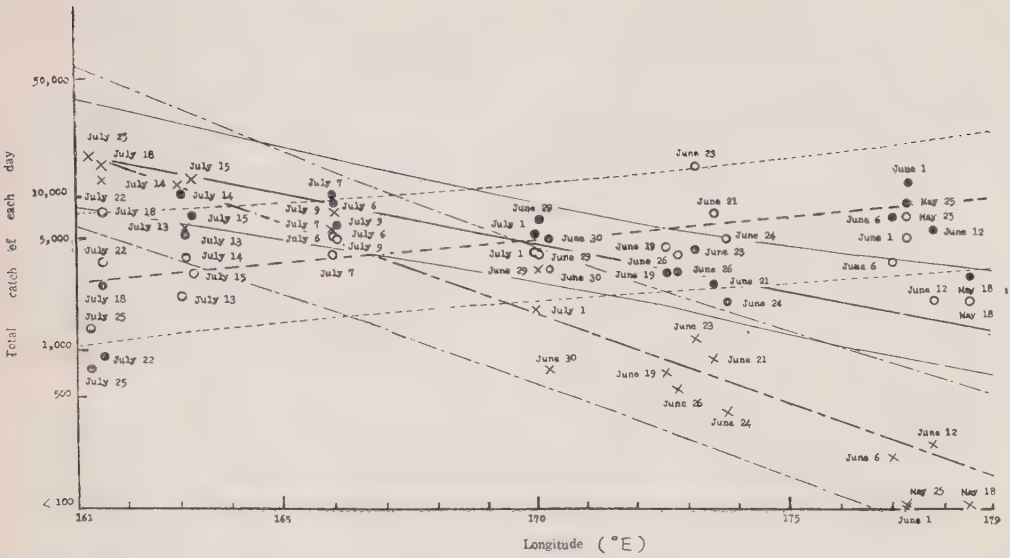

Fig. 2 Daily total catch of *O. nerka*, *O. keta* and *O. gorbuscha*, regression line of each salmon species and the rejective zones.

●: Total catch of *O. nerka* of each day
○: Total catch of *O. keta* of each day
×: Total catch of *O. gorbuscha* of each day
———— : Regression line of *O. nerka*
— — — — : Regression line of *O. keta*
——·——·——: Regression line of *O. gorbuscha*
: Rejective zone of *O. nerka* at 0.05 level of signigicance.
---------- : Rejective zone of *O. keta* at 0.05 level of significance.
——·——·——: Rejective zone of *O. gorbuscha* at 0.05 level of significance.

Reasonably, some habits of salmons may be considered as being different at the two sides of this longitude.

Conclusion and summary

Summarizing these results, the longitude, 173° 12′ 50″ E. may be accepted not only as the longitude of the minimum land-influence, perhaps the boundary between the area influenced by the Kamchatka Peninsula and that under the influence of the Near and Rat Islands, in the season of 1952, but also as the critical line of some other biological phenomena, although there remains a certain doubt as to whether some untouched biological factors, for instance the problem of stock, must be considered in the present analysis.

Table 4. Biological characters of salmons and their changes

	Off the Near and Rat Islands	Off the Kamchatka Peninsula
O. nerka	The average length of specimens measured between June 3 and June 9 was 21.77 inches.	The average length of the specimens measured between June 14 and June 20 was 22.15 inches.

The average weight of these same specimens was 5.34 pounds.

Stomachs of all fishes taken from these waters were markedly distended (June 3—June 9). Red salmon taken on June 14 and 15 were feeding very lightly or not at all.

The average weight of these same specimens was 6.2 pounds.

Heavy feeding was indicated in all of these fishes landed from June 16 to June 18. Stomach contents of these fishes showed a marked decrease in squid, and lantern fish were no longer seen. Many of the stomachs of salmon taken in the fishing area south of Agattu contained juvenile cod.

On June 14 the composition of the catch changed, with the number of red salmon decreasing and the number of chum salmon increasing. Also, an abrupt difference in the body proportions of the red salmon was noticed. Red salmon caught on that day were noticeably stouter and more deep-bodied than those previously encountered.

Throughout the month of May the fish were frequently caught in equal numbers on both faces of the net, regardless of the direction of the set. From June 1 to June 8, randomness was still evident, the fish approaching from the N., NE., ENE., ESE., S., SW., and W. From June 9 the direction of approach of the fish was from the south to the east.

O. keta

Variation in the size of the chum salmon caught was striking in the area south of Kiska Island.

The average size of this fish caught in the water south of Kiska was 22.1 inches.

The average weight was 5.1 pounds.

On June 19 the variation in size became less noticeable.

The average size of the fish (average length 21,1 inches weight 4.1 pounds) appeared to be less than that of the chum salmon taken previously in waters south of Kiska Island.

* Beginning July 1 a great variation in the size of fish in the catch became apparent.
* All stomachs examined showed evidence of heavy feeding until June 26.
* Almost no food was evident in most specimens taken from June 27 to July 4.
* A great variation in size of chum salmon was evident in the catch from July 1 to July 18.

* As with the red salmon, great variation in the degree of gonad development was evident in the chum salmon taken in waters south of Kiska between June 1 and June 24.

* The degree of sexual maturity of chum salmon taken from waters south of Agattu Island from June 26 to June 30 was uniform.

O. gorbuscha

No secondary sexual characteristics were apparent in the fish taken south of Kiska Island between June 1 and Jnne 14.

Pink salmon with hump began to appear on July 1, but in relatively small number at that time. Beginning on July 4, an increase in the number of hump-back specimens occurred.

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Studies on Naturally Occurring Suspended Organic Matter in Waters Adjacent to Japan (II)

(On an Application of the Suspended Organic Matter for the Analysis of Water Masses)

by Tokimi Tsujita

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The larger, suspended organic matter in the seas surrounding Japan has long been known as "Nuta". Its appearance and some remarkable features have been noted in several oceanographic works. Some accounts on the suspended organic matter in lakes and rivers in Japan also have been published. In these works, two forms of susppended organic matter are generally recognized, namely, particulate and dissolved organic matters.

Tsujita (1953)* examined the larger, suspended organic matter naturally occurring in the seas adjacent to Japan, especially with respect to the origin and biotic constituents of the organic matter present in spring and summer.

According to his studies, the appearance and its biotic constitution follow the explosive multiplication of some speacies of plankton.

§ 1. *Suspended organic matter without plankton community in its constitution.*

The suspended organic matter

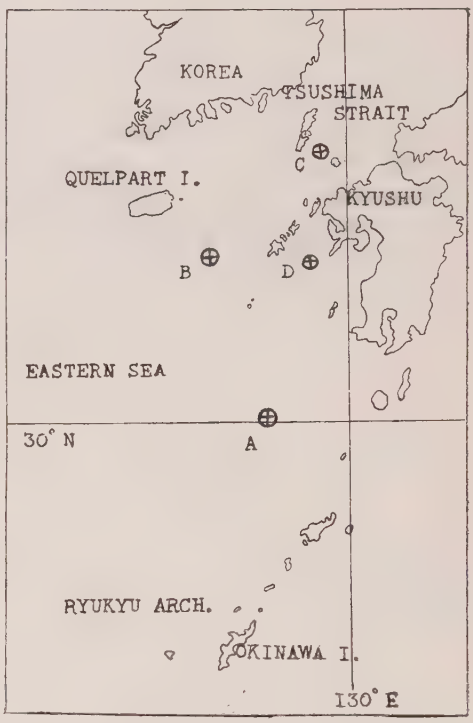

Fig. 1. Chart showing the localities where naturally suspended organic matters and an underwater photograph of the organic matter at 75 m. layer ⊕ have been taken,
A . . . Lat. 30° OI'N., Long. 128°34.5′ E. in the Eastern Sea)Fig. 1 in Plate)
B . . . Lat. 32° 48′ N., Long. 127°30.5′ E. in the Eastern Sea (Fig. 2 in Plate)
C . . . Lat. 34°00.5N′., Long. 129°32.5′E. in the Straits of Tsushima (Fig. 3 in Plate)
D . . . Lat. 32°35.2′ N, Long. 129°23.5′ E in the Sea of Gotō Nada (Fig. 2)

* Tsujita, T. 1953. A preliminary Stutdy on Naturally Occurring Suspended Matter in Waters Adjacent to Japan. Journ. Oceanogr. Soc. Japan, Vol. 8, No. 3-4.

considered by the author are large and called "Nuta" or "Yogore" in Japan. They are found particularly in the boundary of water masses. From the study of samples collected during an oceanographic observation made in February, 1952, it may be said that suspended organic matters are distributed not only in coastal waters but also in offshore waters like the Eastern Sea. As shown in Figs. 1 and 2 in Plate, the the matrix constitutes the main portion of the suspended organic matter in the waters of the Eastern Sea in contrast to the large proportion of plankton sometimes found in the waters south-west of Japan. Figs. 1 and 2 in Plate are samples collected during the observation made in 1952. Those were found in the boundary of water masses between the Central Cold Water of the Yellow Sea and the Tsushima Current. Identification of their constitutions, especially the fact that the matrix is the only biotic constitution, indicates that these organic matters were formed during the season when the plankton population was growing explosively.

§ 2. *Suspended organic matter in an intermediate water-layer in the Straits of Tsushima*

Particulate organic matter has been presumed to be a cause of turbidity of sea water. Using a bathysphere, the "Kuroshio", for underwater observation, the author has recognized small bodies of organic matter as a source of turbidity of the sea water in the deeper layers also. Fig. 3, Plate, an underwater photograph taken on the 29th of October, 1952, shows the small bodies of organic matter suspended at a depth of 75 meters at Station 2 of the "Kuroshio" Cruise, at a location 109 metres deep in the Straits of Tsushima. The photograph was taken through the observation window at 16th–30 m using the *Tyndall* effect by throwing a beam of light from a 500 W. search light on to the suspended bodies. Small bodies of organic matter scattering the light could be seen, and when some of them approached the window of the bathysphere, the author observed and sketched them. Observed under these conditions, the movements of the bodies in the water-layers were like the scattering of a dandelion's petals. According to the results of our underwater observations from the bathysphere the density of such suspended organic matter was the greatest in the intermediate water-layers and the lowest in the bottom water-layer. After observations of the water temperature and the salinity in several layers as exemplified in Tab. 1, it is clear that

Tab. 1. Results of Underwater Observation by the Bathysphere, the "Kuroshio" at the Station 2 16 M SE of Izuhara in the Straits of Tsushima, on 29th October, 1952.

Observed Layer in metre	0	25	50	99
Water temp., °C	23.0	23.2	23.2	19.5
Chlorinity, cl ‰	18.82	18.84	18.86	19.11
Density in situ	23.19	23.24	23.36	24.97

the higher the density in situ and the stronger the current velocity in the intermediate water-layers, the more densely the organic matter is suspended. In a water column at the observation station, the density in the deeper water-layer was higher than that of the upper water-layer, and the current velocity in the intermediate water-layers was stronger than that of the bottom water-layers. Consequently, the density of the organic matter was the highest in the intermediate water-layers. Since they could not sink downward the visibility is very high in the bottom water-layers. Results of the observations, as exemplified above and in Tab. 1, make it possible to analyse these water masses by the suspended organic matter. In waters of the Straits of Tsushima, the vertical distribution of the organic matter has a connection with the current and the distribution of water masses. The Subtropical Intermediate Water proper to the Tsushima Current flows below a layer 30–50 metres deep, and in the surface waters above this layer, there can be seen water proper to the Continental Shelf Water of the Eastern Sea. It is considered that the upper waters in which the organic matter is densely suspended represents the water proper to the Eastern Sea.

§ 3. *Analysis of stratified waters by the suspended organic matter*

The author formerly studied the current of the stratified waters off Nagasaki in the Sea of Gotō Nada in August, 1948, and succeeded in analysis of the water masses which could be studied by observing the vertical distribution of the plankton community and the suspended organic matter. When a comparison was made between the plankton communities of the upper water and the lower water (Table 2) the plankton community of the deeper water mass seemed simple; so that, neritic plankton was dominant in addition to richness of bivalve larvae in the upper water mass, but the plankton community was simple, and much of the larger suspended organic matter was collected in the hauled plankton net in the deeper

Tab. 2. Comparative Table of the Plankton Communites of the Stratified Waters on 31 August 1948.

Upper Water Mass		Deeper Water Mass	
Thalassiothrix frauenfeldii	CC	*Thalassiothrix frauenfeldii*	C
Thalassiothrix nitzschioides	CC	*Thalassiothrix nitzschioides*	C
Thalassiothrix longissima	C	*Thalassiothrix longissima*	C
Bacteriastrum delicatulum	C	*Ditylum brightwellii*	+
Ditylum brightwellii	C	*Chaetoceros decipiens*	RR
Stephanopyxis palmeriana	C	*Rhizosolenia styliformis*	RR
Chaetoceros decipiens	C	*Corethron criophilum*	RR
Chaetoceros debilis	+	*Eucampia zoodiacus*	+
Chaetoceros sekundes	+	*Coscinodiscus excentricus*	RR
Chaetoceros aequatorialis	RR	*Pleurosigma obscurum*	R
Rhizosolenia alata	R	*Ceratium furca*	+
Rhizosolenia styliformis	+	*Ceratium trichoceros*	R

Rhizosolenia stolterfothii	+	*Ceratium kofoidii*	RR
Leptocylindricus danicus	+	*Triceratium favus*	RR
Corethron criophilum	R	*Tintinnopsis aperta*	RR
Eucampia zoodiacus	+	*Copepoda juv.*	+
Planktoniella sol	R	*Microsetella norvegica*	R
Coscinodiscus excentricus	R	*Lamellibranchia larva*	R
Actinoptychus undulatus	RR		
Trichodesmium erythraeum	C		
Peridinium depressum	RR		
Ceratium trichoceros	+		
Ceratium fusus	R		
Ceratium massiliens	R		
Ceratium semipulchellum	RR		
Ceratium macroceros	R		
Ceratium furca	RR		
Copepoda juv.	+		
Paracalanus parvus	C		
Microsetella norvegica	C		
Mecynocera clausi	RR		
Stegosoma sp.	RR		
Ophiopluteus larva	RR		
Lingula larva	R		

water mass. Although the matrix of this organic matter from the deeper waters could not be distinguished from its biotic constituents, the biotic phase of the plankton community as biotic constituents of suspended organic matter resembles that of deeper water mass as shown in Fig. 2. Therefore, community relationship is recognizable, and not neccessarily the organic matter indicates a character of the deeper water mass.

According to our observations on August 31, 1948, as shown in Tab. 3, the difference in physical properties of these two water masses indicate that the current direction of the upper waters above a depth of 30 metres is from west to north-northwest and the deeper water currents below 30 metres from east to north-northeast. Salinity varies from 33.28‰ at 25 metres depth to 34.20‰ in 40–50 metres layer and there is a severe discontinuity-layer of water temperature in 25 to 40 metres. Under such physical conditions, one may be sure that there are differences between the upper water mass above 30 metres and the deeper water mass below that layer. Such differences of the water masses are emphasized by the biological differences in plankton collected in a layer 30–50 metres deep and samples hauled in the upper water from 30 metres to the surface. In addition, organic matter is present in the deeper water layer below 30 metres. Thus, the suspended organic matter may be used for analysis of the water mass.

Fig. 2. Enlarged drawing of a fragment showing the biotic constitution of the suspended organic matter collected in the deeeper water-layer of stratified waters in the Sea of Gotō Nada, on 31st August, 1948.

Tab. 3, A. Results of Observation of Water Temperature, Salinity and consumed Oxygen at all Depths at the Station of the Current Measurement.

Observed layer in metre	Time	Water temp. t°C	Salinity S ‰	Oxygen consumed by org. matter mg/L
		The 1st day (30th August)		
0	20h 15m	26.4	33.21	1.84
10	20 10	26.44	33.21	2.21
25	20 55	25.80	33.28	1.62
50	20 18	21.77	34.26	1.23
75	20 38	25.25(?)	33.21(?)	1.63
		The 2nd day (30th August)		
20	2 40	26.01	33.28	1.46
40	3 20	22.16	34.17	0.88
75	3 27	18.05	32.79(?)	1.34

Tab. 3, B. Results of Current Measurements at the position 109 m. in Depth, 19 M. West of Nomozaki.

Depth in metre	Time	Current Velocity cm/sec.	Current directions in degree
1	21 h 34 m	0.1	270(W)
1	21 48	22.0	296(WNW)
5	22 03	26.8	
5	22 17	26.0	307(NW)
10	22 45	17.0	317(NW)
10	23 03	45.7	312(NW)
20	23 37	41.7	273(W)
30	1 32	22.5	80(E)
40	1 50	88.5	19(NNE)
40	2 30	83.6	18(NNE)

Resumé and Acknowledgments

Some relationships were found between the topographical positions of suspended organic matter in the stratified waters off Nagasaki, its vertical distribution in the Straits of Tsushima and the surface distribution in the boundary of water masses in the Eastern Sea. It appears possible to use the suspended organic matter for the analysis of water masses in the sea.

I should like to express my gratitude to Prof. M. Uda of the Tokyo Fisheries Univertity who provided me with much advice for examining stratified waters, and to Prof. Inoue of the Hokkaido University who kindly let me use his bathysphere, the "Kuroshio", for underwater observations of the suspended organic matters.

PLATE

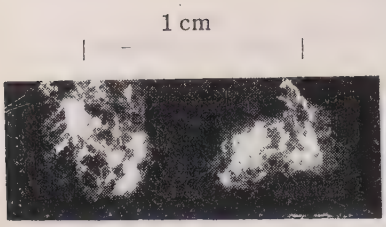

Fig. 1

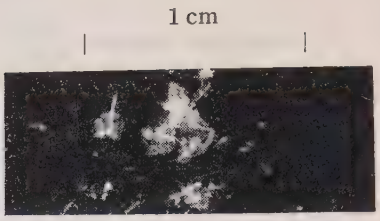

Fig. 2

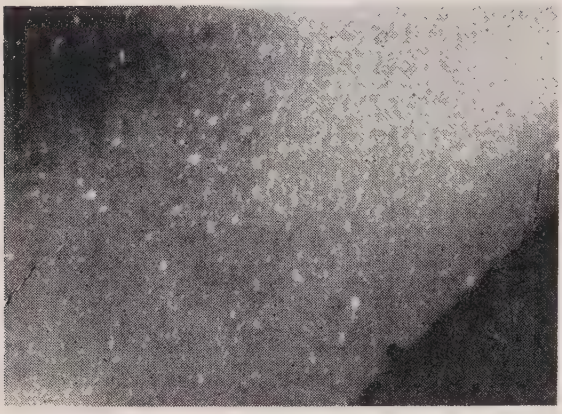

Fig. 3

Fig. 4

EXPLANATION OF PLATE

Fig. 1. Microphotograph showing a sample of the suspended organic matter consisting only of matrix from a dense suspension; collected in the surface water at lat. 30° 01′ N., long. 128°34.5′ E. in the Eastern Sea on the 13th February 1952.

Fig. 2. Microphotograph showing a sample of the suspended organic matter consisting only of matrix from a dense suspension; collected in the surface water at lat. 32°48.0′ N., long. 127°30.5′ E. in the Eastern Sea on the 22th February 1952.

Fig. 3. Underwater photograph showing the suspended organic matter at a layer 75 m. deep, taken on 29th October 1952; photo. by S. Sugimoto.

Fig. 4. Bathysphere the "Kuroshio" hoisted over side of R. V. the Oshoro-maru, showing a perspective of the bathysphere.

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Absorbtion of Fish Scale Caused by Starvation

By Ryushi Ichikawa

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Introduction

It is well known that age determination of fish is possible by recognizing two kinds of peculiar features of the scale, i.e., the seasonal change of the width of circuli and the existence of absorbed or destructed lines which were caused by spawning or some other physical condition of the fish in particular seasons of a year.

Mottram (1931), Crichton (1936), Järvi and Menzies (1936) stated that the spawning mark in the scale was formed by the absorption of the scale margin owing to the maturation of the gonad and to starvation during the spawning season. Creaser (1926), Zamakhaev (1940) and Blackburn (1950, 1951) thought that shrinkage of the body during the spawning season caused the destruction of the scale margin by the mechanical rubbing against each other.

The author intended to clarify the cause of absorption of the scale by obtaining the examples experimentally in relation to the spawning mark and annual ring formation.

Materials observed

The four individuals of Carp, *cyprinus carpio*, were reared in a tank, about 1 cubic meter in quantity kept inside the laboratory at the Fisheries Institute, Faculty of Agriculture, Tokyo University, during the colder half of a year. They were fed a minimum amount of food just enough to maintain their lives, in order to keep them in starvation during the whole period of rearing.

Table 1.

Fish	Date started	Body weight at the beginning	Date died	Body weight at death
No. 1	Sept. 8th, 1950	32 g.	May 30th, 1951	20 g.
No. 2	Sept. 8th, 1950	32 g.	June 1st, 1951	16 g.
No. 3	Sept. 8th, 1950	30 g.	May 30th, 1951	13 g.
No. 4	Sept. 8th, 1950	32 g.	June 14th, 1951	22 g.

As shown in Table 1, these fish lost considerable weight by mal-feeding. The scales were then taken for histological observation and compared with scales from healthy specimens.

Feature of scales

Calcium salts The absorbed scales were sectioned after embedding in paraffin without decalcifying, and the presence of calcium salts was examined by silver nitrate staining.

As shown in Fig. 1, the dark stained layer containing calcium salts in the surface of these scales was found remarkably thinner compared with that of the scale from a normal fish. As this thin calcified layer was found to be the bony layer only, the calcium salts in the underlying fibrillary plates must have been absorbed entirely by some physiological mechanism. By feeling with the fingers, disappearing of the calcium salts could also be noticed easily. It is softer than the normal scale.

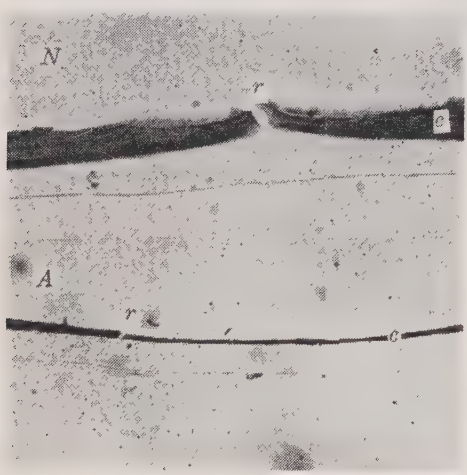

Fig. 1. The calcium salts in scales. (the exposed part)

N ··· Normal scale containning calcium salts in its bony layer and fibrillary plates. ×400

A ··· Absorbed scale lost the calcium salts from its fibrillary plates. ×250

r ··· radius

c ··· calcified part

From this fact, scale absorption in fish is not merely a result of the mechanical breaking off of the edges of scales when the body of the fish shrunk as Creaser (1926), Blackburn (1950, 1951) stated, but also a result of the disappearance of the calcium salt absorbed by a certain physiological mechanism, which would weaken the scale and may bring about the mechanical breaking off.

About this problem Crichton (1935) presented a question whether scale absorption was caused by interruption of secretion of the scale-forming substance by the shortage of food, considering the scale would be a waste-product, or by hypocalcemia as it was observed in case of bones of mammals. The evidence presented here would support the idea that the calcium salts already deposited were absorbed as in the case of the bones of mammals even though the scale is not furnished with living cells and blood vessels.

The crystals of calcium oxalate, which exist quantitatively in the normal

scale of this species (Kato, 1953), was not found in these absorbed scales. This tells me that even the calcium oxalate crystals, an end-product of metabolism, may be used again during starvation.

Marginal parts As Mottram (1931) already stated, I also observed many cases where the margin of the scales was destructed more in the part called "shoulder" than in any other part. Around the entire margin of scales, a belt of the fibrillary plates not covered by the bony layer is recognized. At the surface, the margin of each fibrillary plate runs almost parallel to each other, as shown as the fine scars in *f* (a belt of fibrillary plates) in Fig. 2.

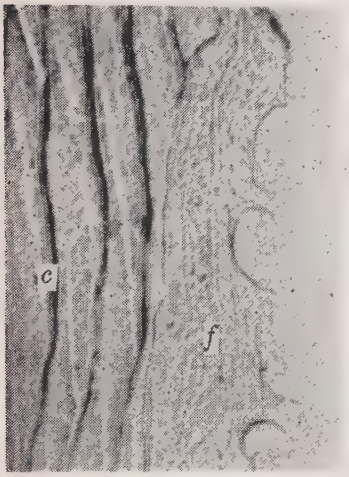

Fig. 2. The absorbed scale margin. (the covered part) ×250

c ····· circuli

f ····· naked fibrillary plates

Focus Besides the marginal area of the scales mentioned above, also at the part of focus, the central area of the scale, a considerable destruction of bony layer could be recognized. The fibrillary plates had become naked and are seen as vermicular patterns in Fig. 3.

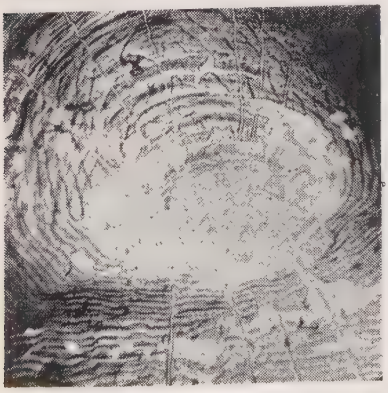

Fig. 3. The absorbed focal area.

(the covered part is lower) × 50

Ridges The other parts of the scale not already mentioned remained less destructed. However, ridges (circuli) running on the surface of the scale were deformed to various degrees. This happened more noticeably in the exposed part of the scale (posterior part) than the covered part (anterior part).

In the exposed part of the scale, especially in the part close to the margin (the lower part in Fig. 3), the destruction of the surface of the scale is so great as to result in the disappearance or interruption of the ridges to various degrees.

In the covered part, (the lower part in Fig. 3) destruction occurs merely at the peak of the ridges, so that it sometimes changes the courses of the ridges, which normally lie fairly parallel to each other.

Concerning the deformation and disappearance of ridges of scales, Järvi and Menzies (1936) already describes about what had happened to the scales of spent salmon. The present case can be said to be similar to that case.

Conclusion

The author wishes to call attention to the fact that the absorption of the scale during mal-nutrition may be caused by the disappearance by certain physiological mechanisms, of calcium salts from once calcified layers, after which the destruction or deformation may take place.

Formerly the destruction was interpreted mainly to be mechanical such as the rubbing of the scale with each other. If this were the case, more surface destruction should be found in the covered part than in the exposed part of the scale, not considering the rubbing from out side of the body.

The author wishes to express his thanks to professer Yoshio Hiyama for his instructive advice and criticism.

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Under-water Animal Sounds around Japan

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Introduction

A large number of narratives and non-scientific descriptions have appeared about the sound producing fishes and the submarine animal sounds since olden times. Nothing is, however, more accurate than that given by Uchida (1934)[1] as far as Japanese fishes are concerned. He listed 44 species, belonging to 26 families, as the sound producing fishes, of wnich 11 species (9 families) were fresh-water inhabitants and the remaining were marine. However, such information was obtained by hearing the sound by unaided ear either diving near the shore or listening to the sound at the aquarium. Besides, the literatures he found reliable were also consulted.

Since 1940, in co-operation with Mr. Ryuzaburo Taguchi, the author has devised several types of under-water microphones with a view to using them in the aquarium to hear under-water animal sounds. Most of them are carbon microphones made water-proof by rubber film and others. The sound waves caught by them were amplified by a 60 W power Mazuda electric amplifier, provided with a dynamic speaker with the use by several observers in view. When necessary, sounds were recorded by acetate disc recorders. These instruments and methods have been improved year by year, while acoustic recording were mostly made in summer time of 1944. After that, the author was obliged to give up the continuance of the research under war-time confusion. The hearing and recording were mainly done in the salt-water aquarium attached to the Misaki Marine Biological Station of the Tokyo University as well as on the open sea around the Station. The research was made in various seasons throughout several years with the sincere assistance of several students, in particular, of Messrs. Takaya Kusaka and Yutaka Murakami.

Besides these experiments of our own, some submarine sound records obtained by the hydrophones of the coast guard of the Japanese navy were put at the author's disposal for analysis and identification of the animal species. The records, however, failed to provide any further information worthy of note except on the species of Dolphins (Odontoceti, Cetaceae), whose sound source had not been identified until that time.

1) Uchida, Keitaro: — Sound producing fishes of Japan (in Japanese) Report of Japan Science Association Vol. 9, No. 2, 1934.

In early September of 1944, the author was asked by the Naval Acoustic Institute at Numazu to investigate the submarine noise which regularly took place in every summer night in the middle of Enoura Bay, although it had been studied from the stand point of physics since several years. By hearing the sound, it sounded like one produced by a school of fishes, such as the Gurnard, "Hobo", *Chelidonichthys kumu*, and the Croaker, "Iseimochi", *Nibea schlegeli*. So in the next morning a trawler hauled the spot identified as the center of noise as well as other grounds for comparison. The analysis of the catch from these spots showed that the fishes of these species known as the sound producers were more numerous in the center of the noise than in other places.

These informations on the sounds produced by the aquatic animals which were obtained by the experiments and experiences of our own are supposed to have much improved those already obtained by Uchida (1934). To the fish species recognized by him as sound producers, I have, indeed, added so numerous fish species that it seemed to be of little value to improve his list from the stard-point of taxanomy. In fact, it would have to include almost all the fish kinds living in this country. Such being the situation, the classification of the underwater animal sounds was made from the ecological standpoint, as was tried in my book where the classification remained rather sketchy, because it was thought more reasonable and convenient for the identification. According to the proposed classification, there are (1) Feeding sounds, (2) Swimming sounds, (3) Warning sounds, (4) Mating sounds (5) Breathing sounds and (6) Struggling sounds.[1)]

The author wishes to express his thanks to Dr. I. Amemiya for his kind suggestion and encouragement which enabled this work to be reported here.

1. Feeding sounds

This is a group of sounds produced at the time when the animals eat food of various kinds, other than minute or soft organisms such as plankton.

Sound producing mechanism These sounds are mainly produced by knocking and rubbing of foods by oral apparatuses, such as lips, jaws, jaw teeth, pharyngial teeth, mandibles, maxillae, maxillipedes and others, and also by knocking and rubbing of these oral apparatus by each other. The sound is particulary loud when the food is hard, being, for instance, barnacles, shellfishes, sea-urchins and the like. It is to be remarked, however, that the knocking sound is considerably noisy, even if the food is soft.

Characteristic of sounds Knoking sound. The interval is entirely irregular. If it is caused by a single fish, it sounds like - This is artificially reproduced by two small stones struck together by hands. If there are many fish as in the case of a fish school, the sound interval is shortened, so that it sounds more often and finally becomes continuously sound-

1) For the English translations of these terms used in this classification, the author owes Dr. Katsuma Dan, and wishes to express his thanks to him.

ing. It is like the sound produced by numerous gravels knocking each other in a rapid current. However, it is peculiar to these eating souds that some knocking sounds are loud and some faint.

In the case of Crustacians, the noise is rather continuous even in the case of a single individual. It sounds like the noise caused by rubbing a hard paper continuously.

Occurence There is no particular season for its occurrence. But it usually occurs more frequently in summer than in winter. It takes place more often in day time than at night. But some nocternal feeders, such as some Crustaceans, make noise during night. If we place a hydrophone on weedy and rockly shore and let it stand on the bottom for a few months allowing many barnacles and other organisms to settle on its surface, the fish noise very often sounds like a knocking by a hammer, as the fishes swarm to the place to eat various organisms on it. It was also reported by a boat furnished with a hydrophone that this sort of noise was heard after gavage was thrown out from the board, probably, attracting fishes to come and eat it.

Animal kinds Numerous fish species have been tested in the aquarium, fed with various kinds of foods, hard and soft, and all of these species have been found to be sound producers when they eat any sort of food. So, I am fairly convinced that if we could test more fish species than we have tested we would be able to add more to the list of the fish which produce feeding sound, and that almost all fish species are moise makers of this kind. One of a few exceptions is the fish belonging to plankton feeders, such as the Sardine, *Sardina melanosticta*, and the Horse mackerel, *Trachurus japonicus* of 10–20 cm long. A school of these species were fed by plankton, *Mysis spp* mainly, but the author failed to recogize any noise by hydrophone.

The loudest noise makers in eating are the fishes belonging to Monacanthidae, such as *Monacanthus cirrhifer*, *Rudarius ercodes* and *Cantherinus modestus*. There may be other species of this family which also produce sound when eating, but they were not tested by us. Even when soft food such as fish meat is given, the noise comes out from the aquarium to be heard by unaided ear. Even after they finish eating, the noise continues for a while, as they are still knocking the both upper and lower jaw teeth.

The fishes belonging to Teraodontidae, such as *Spheroides niphohles*, *S. pardalis*, *S. chrysops* were tested and proved to be noise makers, while other species of this family are also supposed to be of the same nature.

The fishes belonging to Oplegnathidae are known[1] to have a habit to eat hard shelled organisms such as barnacles and sea-urchins. These rocky shore inhabitants, *Oplegnathus fasciatus* and *O. punctatus*, were proved to be loud noise makers when they eat the food of this kind. *Sparus swinhonis* and *S. aries* are also provided with the same habit. It is further supposed that the fishes having

[1] Hiyama, Yoshio: On the development of teeth of *Oplegnathus fasciatus*. Dobutsugaku Zasshi, Vol. 46, No. 549, 1934.

a feeding habit like that of 'knocking birds' would produce similar noise, and there may be many species of this kind which are still remaining to be tested.

Some of the fishes having a habit to eat living fish were proved to make a single knocking noise when they gulp the victim. For example, fishes of Serranidae, such as *Lateolabrax japonicus, Epinephelus septemfasciatus, E. moara* are found to produce noisy sound when they gulp living fish such as sardine. The fishes belonging to scorpaenidae, such as *Sebastiscus marmoratus, Pterois lunulata* were also proved to be the same. It would be the same in the case of any other fish having the same food habit.

Even in case of the fishes which eat small organisms, such as *Therapon oxyrhynchus, Parapristipoma trilieatum*, and *Halichoeres poecilopterus*, considerable noise was recognized. Moreover, the fishes recognized as eating algae and other small organisms which settle on the surface of rock, such as Bryozoa and others, are found to be noise makers when they eat these soft foods. *Siganus fuscesence* and *Xesurus scalprum* are the examples we tested.

Some of the freshwater fishes were tested in the tank. Though the size of these fishes are small, all the fish species we tested, *Cyprinus carpio, Carassius auratus* (both Crucian carp and Gold fish) and *Misgurnus anguillicaudatus* are recognized as sound makers when they eat food.

By these experiments, I have come to the conclusion that all the kinds of fishes, except some plankton feeders which have not been tested, may be noise makers of various strength and characters.

Only a few species of the Crustacea were tested for this purpose, but all of them are reconized as noise makers, and their eating sounds greatly differs from those of fishes. They are not knoking sound. Just like rubbing sound of hard papers, weak noise monotonously continues, while they are eating. Though the sound a single animal produces is not so loud, it is considerably noisy, in case they are numerous. The crabs such as *Atergatis spp* and the Hermit crabs of unidentified species (about one inch long) were tested in the aquarium and found to be sound producing.

Neither mammals nor molluscas were tested.

2. Swimming sounds

It is supposed that some sorts of waves take place when fishes swim in the water. But they are not audible by the hydrophone in our experiments. The squids and cuttlefishes, however, produce a sort of audible noise when they swim in the aquarium.

Souud producing mechanism The sound is supposed to originate from the vibration which takes place at the part of the siphon when the water in the mantle cavity is poured out through it with considerable pressure pushing forward the squid.

Characteristic of sounds If the animal lives as a single individual like in the aquarium test, the sound occurs almost periodically. But when numerous animals

pass the hydrophone, it would be almost a continuous noise. However, in actual cases, in which the sound is produced while they are swimming, the sound takes place gradually, and after becoming loudest, it fades away gradually. A single sound is something like that of tearing cloth or whistling quickly.

Occurence Nothing was reported about the field experience, except the aquarium test. It is supposed to be numerous by occurring, where the squids and culltfishes are abundant.

Animal kinds The cuttle fish species we tested is *Sepioteuthis lessoniana* only, but other species of this sort of animal may also be sound producing. No mammal was tested. All the fish kinds we tested were negative.

3. Warning sounds

Some of the aquatic animals have a habit to make sound when they notice the approach of their enemy or predator.

The sound of this kind is called here 'warning sound'. The sound producing mechanism is however different in each species.

Characteristic of sounds Neither continuous, nor knocking sound, except in the case of the Snapping shrimp. A single loud noise, like a blow of trumpet, or an alarm whistle or a honk of automobile. But, if the animals are numerous producing sound not simultaneouply, it sounds like the noise in the city caused by heavy traffics.

In view of its biological meanings, this kind of noise often happens quite suddenly as a result of the approach of predator animals, powered boats or human beings. And it continues only for a relatively short period, even in case the sound making animals are numerous. These are some of the characteristics which are available for distinguishing the sound from the mating sounds to be described in the next chapter.

Occurrence No particular season for occurrence. It takes place at any place where these particular animals are living. As it was mentioned, this kind of sound occurs as a result of stimulus applied to these animals except in case these animals are silent.

Animal kinds (1) Fishes. Gurnards, *Chelidonichthys kumu*, and *Dactyloptera orientalis* are well known alarm makers. They were also proved to be so by our experiments. Alarm sounds of these fishes are loud enough (over 20 d. b.) to scare the observer outside the thick glass of the aquarium where these fishes are kept. The sound is something like a blow of trumpet or horn. The air-bladder of these species are furnished with strong muscles, and this is supposed to be the organ to produce sound by vibration. *Therapon oxyrhynchus* is also an alarm making fish provided with the similar apparatus at the air-bladder. As it may be understood from the mechanism of sound production, the alarm sound of these fishes is reproduced by rubbing the surface of rubber balloon by a finger. (2) Crustacea. The Common Spiny Robster, *Panurilus japonicus* is found to be a loud alarm maker. It has a habit to suddenly raise the second antenna, when the

things it supposes to be the predator approach and threatens it. An alarm which sounds like "Ghee", occurs at that time. This sound is caused by rubbing a small pad attached to the second antenna against rough surface of a keel furnished with its basal segment. This sound is artificially reproduced even by dead or fixed specimens, quickly letting stand the second antenna by hand. The snapping shrimps, *Alpheus* (*Crangon*) *spp.* inhabiting in a large number on the sandy beach of Japan, are well known noise maker, which so often scare the pedestrians on the beach by sudden shower of their distinct noise. These animals are living in the intertidal zone. Therefore during the low tide, the sound usually comes out to air without being caught by hydrophone. When they produce the noise in the water during high tide, it is, however a considerably loud noise which is heard by hydrophone. This sound is apparently caused by snapping chelae being a sort of knocking sound. However, these animals are usually living on the beach in a group of a large number, so that hundreds and thousands of individuals make the knocking noise almost in unison, in case any predator, boat or predestrian, comes close to them. So the underwater sound caught by hydrophone somewhat resembles a sudden brush fire, and some times it continues for a few minutes. The noise is very loud though the shrimp is about one inch long.

4. Mating sounds

This is a group of animal sounds caused either by one sex or by both sexes of the animal in order to attract the other sex or to indicate their own inhabiting location to the other in the breeding season.

Characteristic of the sounds The single sound is like a blow of a trumpet or rubbing tone of a rubber balloon by a finger. This is repeated almost periodically for a time as long as several hours. As the fishes are always living in a group of a large number, a croak of an individual is usually followed by a large chorus, but their periods are not coincident. This kind of sounds, when it takes place in sea, very much resembles the chorus of frogs in their mating season in marsh or that of numerous singing insects in summer night. However, if fish are so numerous or the hydrophone is so sensitive as to be able to catch the sounds from a vast area, the sounds are very much like a certain mechanical noise which is produced by bubbles or gravels, as it actually deceived the naval technologists of physics for several years as was already mentioned.

Occurence and Animal kinds The fishes known to be in this category are the Croakers, fishes belonging to Sciaenidae. We failed to let any of these species to sing inside the aquarium and record the sound. However, 'Shiro-guchi' or 'Ishimochi' *Nibea schegeli*, which comes up near the river mouth during summer time to spawn, is recognized to be a noise maker of this category by the experience described in the introduction. Many fishermen who have the experience to be on board a trawler in Yellow Sea and East China Sea told the author that the noise of these fish species were so loud during nights from May to July in these

areas that it came out to the air disturbing the sleep of sailors. They believed that several species of the Croakers, Sciaenidae, would have a similar habit. In the coast south of the middle part of Japan, only one species above mentioned is distributed and makes this remarkable noise. This species is abundant in bay areas with clear water, and in the spawning season it approaches the coast having any river mouth near by. As the spawning season is summer, the occurrence of this sounds is confined to the night of this season.

5. Breathing sounds

These are the sounds produced on the occasion of breathing. As all the fish species have the gill as their respiratory organ, which breathes the oxygen dissolved in water, no noise is generated at the time of breathing. However, the aquatic mammals have to breath air when they come out to the surface of water as quickly as possible, so the rapid air current through their nostrils produce vibration around them. The most remarkable noise makers of this kind are various species of Dolphins (Odontoceti, Cetacea), found in the coast and high sea. These animals have their swimming habit which is fairly periodical and come up to the surface of water and then dive down into water, so the breathing sound takes place quite periodically as if there were only a single animal in the sea. However, as the most of the species belonging to Dolphins are usually swimming in a group of a large number, almost all the noises actually caught in the sea are rather irregular. A sound record obtained by the coast guard which was recognised as that produced by this animal was examined by the author, and it was something like a screaming and shouting of numerous children or wemen when they were playing on a crowded summer beach. There is a possiblity of the acoustic source of this kind of sound of being observed on the surface of water if it happens in day time, although it may be hard to identify the animal to the species. If a hydrohone is settled at a certain spot, this sound will come out gradually and fade away at a distance as the acoustic sourse is moving.[1)]

By the experience of those on board whaling boats, various kinds of whales are known to make a loud blow sound when they breath. The author thinks a certain acoustic record obtained by the coast guard possibly contains the sound, but the species is unknown.

6. Struggling sounds

These are the sounds which do not occur in nature, but take place when some human activity such as catching fish, is in existence against the aquatic animals.

During the course of our experiments, underwater noise was heard quite frequently in the aquarium when the fish was forced to be caught or at the instant

1) An example given by a Naval acoustic officer to the author is as follows: an alarm was ordered at a night in war time as a moving sound which resembles a boat was reported at Tokyo Bay, but nothing happesed after that and the officer thought that dolphines fooled the coast guard.

to be taken out from the water. On the other hand, a hydrophone settled near the fishing net could catch the noise produced by the fish when the net was closed and the fish were going to be taken up.

The most remarkable noise maker of this category is the Puffers, or the fishes belonging to Tetraodontide. All the species of this family already described in the chapter 1, as feeding sound makers, are proved to be the sound makers when they are going to be taken out from the water. The sound is sharp and short, and sounds like 'Kyu kyu' apparently originating from the gut when they gulp either air or water. A sort of eel (Apodes), *Ophichthys sp.* is found to be a peculiar sound maker when it crowls in the shallow aquarium and is going to be caught by hands. It vibrates the tip of opercles and makes an relatively long sound which sounds like 'Rhee'. Further, a freshwater fish, the loach, *Misgurunus anguilicandatus* is known as a sound maker when it is caught by human hands. A clear screaming sound of this fish is supposed to come out from some part of the digestive system, as the vibration is felt by the finger. Though these sounds are caught by hydrophon, they sometimes come out to the air to be heard by human ears.

So many kinds of fishes were found in the fishing net that it is hard to identify the sound makers in them hearing the noise by the hydrophone settled near.

This sort of fish sounds might constitute a part of the warning sounds already described in chapter 3, but the main difference from it is that this would not occur unless some substance such as a finger, stick or net touches the fish body, while the other are produced merely by recognision of some strange animals or substance.